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SPECIFIC COMPOSITION OF REPRESENTATIVE FEEDLOT WASTES: A CHEMICAL AND MICROBIAL PROFILE

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ERRORS

p. 29 - Glucose under Fiber Fraction,
Av. value: change 33 to 328.

p. 67 - Total for Feedlot D, sample 3:
change 73 to 63.

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SPECIFIC COMPOSITION OF REPRESENTATIVE FEEDLOT WASTES: A CHEMICAL AND MICROBIAL PROFILE

G. R. Hrubant, R. A. Rhodes, and J. H. Sloneker[1]

Feeder cattle and hog operations have steadily increased concentration and number of animals per unit (feedlot and confinement housing). As a result, large quantities of animal wastes may accumulate and could constitute a pollution hazard. A number of approaches have been suggested for the disposal or use of these wastes.

Among these are drying and refeeding to the same or different species of animals, partition to obtain fractions of enriched nutritive value, fermentative conversion to microbial protein, use as a supplemental nutrient in fermentation processes, composting, land application to increase soil tilth, and generation of methane fuels by anaerobic digestion.

All approaches except the first two involve biological conversion in some form. The most desirable of these are intended to use the inherent value of the waste (a resource, not a residue). However, evaluating the potential for any given conversion and predicting the changes, which may occur under a given circumstance, depend upon knowledge of the material involved.

As far as can be determined, the chemical and biological properties of animal manures are little documented. A survey of the literature, personal inquiry, and two CRIS searches have not disclosed information on exact composition. Data on the physical parameters include quantity per animal and solids content (total and volatile). Chemical data generally reflect such interest in fertilizer value as percent content of nitrogen, phosphorus, and potassium (expressed as N, P_2O_5, and K_2O, respectively). Chemical measurements also include pH, volatile acids, and alkalinity.

Biological properties have been measured as biochemical oxygen demand (BOD) or chemical oxygen demand (COD) and occasionally in terms of gas formation. Changes in these criteria have been used to evaluate methods for stabilization of the waste. However, most numerical data cited in the literature include bedding, a material no longer used in most confinement animal-production units. In any event, no assurance is evident that even these sparse data are representative of feedlot wastes as they exist because they generally represent samples from a single site.

Feedlot waste contains original feed, feed in all stages of digestion, digestive and metabolic products of the animal, cells and products of microorganisms within the animal and those active on the deposited waste, and dirt. Procedures used in the treatment and disposal of municipal sewage have been applied to animal wastes, unsuccessfully, because of unrecognized fundamental differences between sewage and manure.

The studies presented in this publication may contribute to the need for more detailed information on the qualitative and quantitative presence of specific classes of organic compounds and inorganic constituents in feedlot wastes.

FEEDLOTS AND SAMPLING

Feedlots

Rationale for selecting the test feedlots was based on using only those in the Central and Southwestern States, using only feedlots of over 1,000 head capacity, and using feedlots where correlating results to climate could be attempted. Emphasis was placed on cattle feedlots because the large quantity and concentration of wastes from these operations pose pollution hazards. More than two-thirds of the beef marketed in the United States comes from feedlots of over 1,000 head capacity. In 1976, over

[1] Microbiologist, assistant Center director, and former chemist, Northern Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, 1815 N. University, Peoria, Ill. 61604.

TABLE 1.--Profiles of feedlots and sampling

Feedlot designation	A	B	C	D	E	F	G	H	I
Location	Greeley, CO	Olton, TX	Red Rock, AZ	Oakley, KS	Blair, NE	Dallas Center, IA	Hubbard, IA	Fairmont, MN	Pierce, CO
Type	Cattle: all types	Cattle: all types	Cattle: all types	Cattle: all types	Cattle: all types	Farmers hybrid hogs	Cattle: all types	Cattle: all types	SPF purebred hogs
Animals/lot[1]	100,000	22,500	18,000	17,500	12,000	8,000/yr	6,000-8,000	1,500	500-700 piglets, 300 sows
Animals/pen[1]	125	125	100	80	300	15	500	500	20
Space/animal[1] (ft^2)	125	141	136	250	245	10	36	55	5
Age of animals[1]	8 mo - 3 yr	15 mo	12-15 mo	18-24 mo	18 mo	8 wk - 6 mo	18 mo	18 mo	Piglets + 2 yr sows
Floor	Dirt	Dirt	Dirt	Dirt	Dirt	(Inside) cement - slot	Cement	Dirt	(Inside) slotted and solid
Date last cleaned before Summer 1971	Apr 71	Aug 70	May 71	Kept continuously clean	Continuously scraped to manure pack	Slotted floor cleaned continuously	Cleaned often	Previous day	Cleaned continuously
Manure pack at collection time[2]	1: 4 in. 2: 12 in. 3: 3-6 in. 4: 6 in.	All: 4 in.	1: 3-5 in. 2: 10 in. 3: 3-5 in. 4: 3-5 in.	All: no manure pack	1: none 2: frozen 3: 2-3 in. 4: none	All: none	1: 1 in. 2: frozen 3: none 4: none	1: none 2: frozen 3: 12 in. 4: 1 in.	All: none
Sample description at collection time	All: fresh (AP samples): dry (manure pack: A samples)	All: dry surface on very hard pack	All: very hard pack	All: 2 lb fresh + 2 lb dry + 1b from manure pile	All: fresh + dry + wet	All: fresh	All: fresh + dry + wet	1: fresh + dry 2: fresh + frozen 3: fresh + dry 4: fresh	All: fresh from floor

Weather conditions at collection time	1: hot, dry 2: thawing 3: dry 4: hot, dry	1: recent rains 2: warm, thawing 3: hot, dry, windy 4: recent rains	All: dry, hot	1: dry 2: thawing 3: dry 4: dry	1: warm, dry 2: snow 3: dry 4: cool, cloudy	All: cool	1: dry 2: cold 3: dry 4: cold	1: warm 2: snow, cold 3: wet 4: warm	All: cool
Insecticides:									
Name	CoRal	Warbex[3]	None	CoRal[4]	None	None	CoRal	Lintox D	None
Dosage/animal	0.25%	2-3 oz		INA[5]			INA		
Method	dip	Pour on		Dip			Pour on	Spray	
Antibiotics:									
Name	Aureomycin	None	None	Aureomycin	Chlortetra-cycline	Tylosin	None (or As-700)[6]	Combiotic	Furazolidone (NF-180 Furox)
Dosage/animal	70 mg/d[7]			70 mg/d	INA	INA	(300 mg/d)	INA	1 tbsp/d
Method	In feed			When sick	INA	In feed		INA	In feed
Hormones:									
Name	DES[8]	DES	DES	DES	DES	None	Stilbes-terol	DES	None
Dosage/animal	10 mg/d[7]	INA	INA	10 mg/d	10 mg/d		10 mg/d	10 mg/d	
Method	In feed	INA	INA	In feed	In feed		In feed	In feed	
Diet	40% corn and wheat, 60% corn silage and/or alfalfa, + 1.5 lb/d protein-vitamin-mineral supplement	"70 M Cal ration" - milo, wheat alfalfa, cotton seed hulls with supp. of molasses, animal fat, meals and trace minerals of Ca, P, Co, Mg, Mn, Fe sulfate	Barley, wheat, alfalfa + 4% supp. of cotton seed and soybean meal, urea, salt, trace minerals	12.5% alfalfa, 7.9% corn, 25% wheat, 7% corn silage, 35% high moisture corn, 2.2% animal fat, 2.5% supp. (salt, stilbes-terol, bi-carbonate	13% hay, 4% molasses, 62.4% corn, 15.6% barley, 5% supp. (30.6% protein, 5.6% salt), 4.8% Ca, 20% P, 15.8% protein equiv. non-protein N source	13% protein, 87% corn	85-87% corn + protein, 8-10% silage	64.9% sweet corn, 29.5% corn, 4.7% protein supp., .35% limestone, .45% salt	MoorMan's Feed and corn

[1]Values given for collection 1. [2]Collection times: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972. [3]For grub control. [4]Wetable powder (25%). [5]Information not available. [6]AS-700 used during collection 3 only. [7]After 30 days no aureomycin, 20 mg/day DES. [8]Diethylstilbesterol.

85 percent of all cattle were in feedlots of 10 states: Texas, Nebraska, Kansas, Iowa, Colorado, California, Illinois, Minnesota, Arizona, and Oklahoma (in decreasing order); 55 percent were in the six Midwestern States listed. Evaluation of the feedlot waste representative of circumstances in these States was therefore desirable.

Analytical data from feedlots should reflect variations that may be associated with the type of physical facilities used, diet (including antibiotics and hormones), and, of course, type of animals (cattle or hogs). To obtain definitive data, sampling from a given feedlot was necessary over a given period. When each sample was taken, information on the type of animal and its diet was noted for correlation with the analytical results. Both pristine and standard surface samples from the same pen on one feedlot were examined to detect changes associated with aging of waste.

Usually fewer animals are involved in a given feeding operation when hogs are reared in confinement. Although hog feeding generally is done on individual farms with sufficient adjacent land for disposal of the waste as fertilizer or irrigable waste, proper retention and efficient stabilization of this waste to eliminate odor and runoff pollution is also a major concern. This problem too should benefit from information on composition.

The seven cattle and two hog feedlots selected were from the major cattle producing States of the Midwest and Southwest. Cattle feedlots ranged from 1,500 to 100,000 head per feedlot. The general information at these feedlots is given in table 1.

In addition, the microbiology of waste, runoff, and associated sites of an eighth cattle feedlot were examined in greater detail. This feedlot is described in the section on microbial analysis, page 56.

Sampling

Each sample, approximately 5 lb wet weight, was a representative composite of five samples from a selected pen on each feedlot. Where possible, the same pens were sampled for all four collections (sampling times). The fourth collection for Feedlot H was from a nearby feedlot because Feedlot H ceased operation.

Samples were collected with a clean spade. To avoid cross contaminating one feedlot with bacteria from another, the spade was washed with soap and water followed by an alcohol rinse after each sample was taken. Samples were placed in 12- by 30-inch polyethylene bags and were mixed by kneading the bag. An aliquot for bacteriological analysis was removed from the mixed sample and placed in a sterile Whirlpak bag;[2] these were stored in an ice chest during transit and later in a refrigerator until analyzed. The remainder, destined for chemical analysis, then was immediately frozen in a Dry Ice chest and remained frozen until analyzed.

FRACTIONATION OF SAMPLES

Weights were determined by drying samples at 105° C to constant weight. This procedure was followed on all samples and fractions were kept frozen in appropriate quantities until analytical work was done.

Remove 150 g (dry wt) from the frozen sample and dilute to 1,000 ml with distilled water (15 percent solids). Mix well. Let stand overnight in refrigerator. Blend 3 min at high speed in Waring Blendor. Remove a 13.3-ml aliquot and a 6.7-ml aliquot for standard waste analyses.

Fiber Fraction

Pass the remaining 980 ml thru an 8-inch, 20-mesh screen using vacuum. Rub and scrape the residue to remove most of the liquid. Reserve screened filtrate for further fractionation—material remaining on screen is the fiber fraction. Remove fiber fraction from screen and resuspend in distilled water in a 1,000-ml beaker. Transfer to a tared 1,000-ml graduate and record weight and volume. Transfer fiber fraction to blender jar. Reweigh graduate, rinse, and add weight of rinse to total weight of fraction, and add rinse to fiber fraction. Blend briefly, then transfer 2 to 4 ml to tared tube for weight determination. Transfer remainder to plastic cups and freeze.

Soluble Fraction

Centrifuge screened filtrate at 11,000 r/min (average 11,920 × gravity) for 10 min after reaching speed. Decant supernatant, the soluble fraction, into 1,000-ml graduate and record weight and vol-

[2] Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement over products not mentioned.

ume. Mix and transfer about 5 ml to test tube for pH, BOD, and COD. Transfer 2 to 4 ml to tared tube for weight determination. Transfer remainder to plastic cups and freeze.

Particulate Fraction

Quantitatively remove centrifuged residue, the particulate fraction, with the minimal volume of distilled water (300 to 500 ml) required, transferring to tared 1,000-ml graduate. Record weight and volume. Transfer particulate fraction to blender jar. Reweigh graduate, rinse, add weight of rinse to total weight of fraction, and add rinse to particulate fraction. Blend briefly, then transfer 2 to 4 ml to tared tube for weight determination. Transfer remainder to labeled plastic cups and freeze.

CHEMICAL ANALYSES

Methods

Whole waste analyses were restricted to the standard waste analyses. All other analyses were done on all three fractions of each sample except as noted. Chemical analyses and sampling of Feedlots A to I were done by Denver Research Institute, Denver, Colo.

Standard waste analyses

Total solids, volatile solids, and ash.—Measure total solids by drying an appropriate quantity of a thoroughly mixed unfractionated waste sample at 105° C to constant weight. Ash the dried sample at 600° for 1 h; cool; treat with 1:1 nitric acid, which is removed by drying gently; and re-ash at 600° for 10 min. Repeat the nitric acid treatment as required until the sample is free of carbon. The difference in weight between the dried weight at 105° and the weight of the resulting ash after 600° represents the volatile solids.

$$\text{Total solids, mg/g (wet basis)} = \frac{\text{wt of dried sample}}{\text{wt of fresh (wet) sample}} \times 1{,}000$$

$$\text{Volatile solids, mg/g (dry basis)} = (\text{total dry weight} - \text{wt after ashing}) \times 1{,}000$$

$$\text{Ash, mg/g (dry basis)} = \frac{\text{wt of ash}}{\text{wt of dried sample}} \times 1{,}000$$

pH and alkalinity.—Determine the pH of the 13.3 ml aliquot of the 15 percent solids unfractionated waste and of the 5-ml aliquot of the soluble fraction. Reserve the aliquot of the soluble fraction for BOD and COD determinations. Rinse the aliquot of the unfractionated sample into a 100-ml beaker and dilute to about 50 ml with distilled water to improve mixability. Titrite the mixture to pH 7 using a glass electrode pH meter.

Alkalinity is the number of ml of 1 *N* HCl or NaOH required to neutralize 2 g (dry wt) of the waste.

BOD and COD.—Dilute the 6.7-ml aliquot of the 15 percent solids unfractionated waste and the 5-ml aliquot of the soluble fraction to yield a 1-percent solids concentration and freeze until analyses are done. Determine BOD_5 and COD on the unfractionated waste and soluble fraction samples according to the procedure described by the Water Pollution Control Federation (*46*).[3]

The standard COD test was modified by reducing reagent and sample volumes to 2/5 the usual quantities and shortening the oxidation of 2 h to 30 min. Use of a 10-ml Class A microburet permits measurements with a precision similar to that of the standard method. Comparison of the 30-min and 2-h values shows that with most wastes 96 to 98 percent of the oxidation is complete in 30 min.

$$\text{COD, mg/g (dry basis)} = \text{COD of aliquot analyzed} \times \text{dilution factor volume containing 1 g of dry solids.}$$

Carbohydrate

The procedures for finding the soluble saccharides, based on procedures by Sloneker (*38, 39*), and for determining the total neutral carbohydrate, including cellulose and hemicellulose, follow. Procedures for determining lignin and phytic acid also appear below.

Soluble saccharides.—Prepare standards for retention time and detector calibration as follows: Accurately weigh about 5 mg of glucose and 5 mg of sucrose into 15- by 125-mm screw cap vials. Add 1 ml of inositol standard containing 5-mg inositol per ml. Dry standards in oven at 70° C. Carry these standards along with sample determinations.

Weigh accurately 30 to 50 mg of dried fraction into a 12-ml centrifuge tube. Extract each sample four times with 5 ml (each time) 80-percent methanol, warming sample to about 50° C, and dispersing well with a glass rod. Centrifuge (filter if necessary) after each extraction, decant and combine respective supernatants. Retain extracted solids in tared-screw capped tube for cellulose determina-

[3] Italic numbers in parentheses refer to References, p. 93.

tion. To the combined respective supernatants add 0.2-ml inositol internal standard containing 5 mg inositol per ml. Reduce volume to about 2.0 ml by evaporation under dry air stream in N-evaporator at 65°.

Prepare Pasteur pipette mixed bed ion exchange column H^+ and OH^- phase (1:1) and pass concentrate through column into 2-dram vial. Evaporate to dryness as described above. Add 0.25-ml Tri Sil, cap vial and warm to about 50° C for about 15 seconds; let stand 15 min. Inject 0.2 µl for gas chromatographic analysis.

Gas chromatographic conditions were column, 84- by 1/16-inch OV-1 3 percent on 80- to 100-mesh chromosorb w, 8 ml/m Helium carrier flow; single FID, 60 ml/m H_2, 250 ml/m air, 110 ml/m make-up He; 300° C; flash vaporizer = 280°; column temperature program 105° to 235° in 12 min; integrate peaks after elution of solvents.

Determined k values were glucose = 1.12 and sucrose = 0.96
Calculate glucose:

$$\text{mg glucose/g} = \frac{\text{area counts glucose} \times \text{wt inositol} \times 1{,}000}{\text{area counts inositol} \times \text{wt sample} \times k}$$

Calculate oligosaccharides as sum of peaks eluting after inositol and calculate similar to above.

Total neutral carbohydrate.—Prepare standards for retention time and detector calibration as follows: Accurately weigh approximately 5 mg of each standard saccharide into a 15- by 125-mm screw cap vial. Add 1 ml of inositol standard containing 5 mg inositol per ml. Dry samples in oven at 70° C. Carry these standards along with sample determinations.

Prepare samples for gas chromatographic analysis as follows: Accurately weigh 30 to 50 mg of sample into 15- by 125-mm screw cap vial. Add 0.3 ml 72-percent H_2SO_4 and heat to 30° C for 1 h. Disperse sample thoroughly with glass rod during heating period. Add 7.4 ml water and 1.0 ml of inositol internal standard. Cap vials and heat 1 h in oven at 120°. Centrifuge and transfer 2 ml of each sample to individual 12-ml centrifuge tubes. Add solid lead carbonate to neutralize the H_2SO_4. Centrifuge and decant into clean centrifuge tubes. Add to each tube 0.5 ml sodium borohydride (~40 mg/ml) and let stand 1 h. Destroy excess borohydride by adding N acetic acid until effervescence ceases.

Prepare ion exchange column for each sample from a Pasteur pipette. Place small glass wool plug in pipette. Prepare slurry of AG — 50 by 4 H^+ form (200 to 400 mesh) in water. Pour resin into pipette to column depth of 1½ inches. Transfer the borohydride reduced sample to column using bulb and pipette to make transfer. Collect effluent in 15- by 125-mm screw cap vial. Wash each column after sample with 1 ml H_2O and collect water wash. Evaporate sample to dryness at 70° C in oven. Remove borate by adding 1 ml methanol and evaporating sample to dryness. Do this three times. Prepare acetylation mixture (1:1 pyridine-acetic anhydride) and add 0.2 ml to each vial. Cap vials and heat in oven 16 h at 120°. Inject 0.2 µl of acetylation mixture for gas chromatographic analysis. Use chromatographic conditions given in soluble saccharide section.

$$\text{mg saccharide/g} = \frac{As \times Wi \times C \times 1{,}000}{Ai \times Ws \times k}$$

As, Ai = area of saccharide and internal standard (inositol)
Ws, Wi = wt of sample and internal standard
C = conversion factor; 0.88 for pentose, 0.90 for hexose
k = detector response

$$= \frac{\text{mg inositol} \times \text{area count for saccharide}}{\text{mg saccharide} \times \text{area count for inositol}};$$

average k value determinations: arabinose, 0.942; xylose, 0.817; mannose, 0.838; galactose, 1.520; glucose, 0.881.

Hemicellulose is calculated as the sum of the nonglucose saccharides.

Cellulose.—Determine weight of sample in tube reserved from soluble saccharide determinations. Add 3 ml of mixture of 150 ml 80 percent acetic acid and 15 ml conc. HNO_3. Disperse sample with glass rod, cap, and heat 30 min in oven at 100° C. Cool, centrifuge, decant, and discard supernatant. Wash two times each with 3 ml of the acetic acid-nitric acid solution. Wash concentrate two times with 2 ml of acetone. Evaporate the acetone. Analyze the residue as described for neutral carbohydrates.

$$\text{mg cellulose/g} = \frac{\text{glucose area counts} \times \text{wt inositol} \times 0.9 \times 1{,}000}{\text{inositol area counts} \times \text{sample wt} \times 0.881}$$

Lignin.—The procedure for determining lignin in the fiber and particulate fractions is based on a modification by Sloneker and others (*40*) of the method of Van Soest (*45*). The method, with minor changes, is as follows: Weigh 1 g lyophilized sample (dry, finely divided powder) and 200 mg filter-paper pulp (S and S No. 289 Ash-free). Add 50 ml acid detergent solution and 1 ml decalin. Heat to boiling on hot plate for 5 to 10 min. Stir as foaming begins. Boil about 1 min. Heat 12½ min in autoclave at 120° C. Cool to room temperature. Filter through Whatman No. 42 ashless paper in a 2-inch Buchner funnel with aspirator vacuum. Rinse the beaker and wash the mat with 50 ml 95° water, stirring to break up the mat on the filter to get good washing contact. Repeat rinse step. Let funnel

cool a few minutes. Add 30 ml reagent-grade acetone and stir to get good contact. Repeat acetone step twice more, or as often as necessary to obtain colorless filtrate. Pull air through the filter until nearly dry, then transfer funnel to dry 10 min in an 80° oven. Remove and let cool.

Flip the dry filter paper into 7.5 ml 72 percent H_2SO_4 in a 400-ml beaker, which is being cooled in an ice bath. Stir with glass rod to get contact. Remove from ice bath. Leave rod in beaker. Beat and stir periodically to break up lumps and homogenize. Transfer to a 600-ml beaker, using 278 ml distilled H_2O to effect quantitative transfer and washing of the beaker. Use a rubber policeman to assist in the transfer. This transfer is necessary to prevent boiling over in the next step of autoclaving.

Autoclave 1 h at 120° C with heavy Pyrex watch glass on top of beaker. Cool to room temperature. (This step condenses lignin and hydrolyzes the cellulose.) Filter with suction through XF or XFF Selas porcelain frit crucible. Wash with water (50 to 100 ml) until washings are free of acidity. Dry 1 h in oven (110°). Cool in desiccator over silica gel or other desiccant.

Weigh to obtain lignin plus inorganics insoluble in acid. Ignite in muffle furnace at 500° C for 2 h. Cool in desiccator over silica gel. Weigh to obtain residue. Lignin is the weight loss during ashing.

$$\text{Lignin (mg/g dry sample)} = \frac{(\text{wt lignin + inorganic}) \text{ (g)} - \text{wt inorganic (g)}}{\text{dry wt sample (g)}} \times \frac{1{,}000 \text{ mg}}{\text{g}}$$

Phytic acid (as inositol).—The following procedure is based on a method by Sloneker (*39*). Use dry ground fractions. Weigh accurately 0.5 g of material into 15-ml centrifuge tube. Add 10 ml 0.5 *N* H_2SO_4, stopper and shake. Let stand ~15 min with occasional shaking. Centrifuge (filter through glass wool plug, if necessary). Collect liquid phase in S/C tubes (Corning No. 9826). Repeat H_2SO_4 addition and combine filtrates. Reduce the liquid volume to ~10 ml with N_2 in N-evaporator at ~65° C. Adjust pH to 3 with concentrated NH_4OH. Cap and hydrolyze ~15 h (overnight) at 120°. Cool and pass through mixed bed ion exchange column (Pasteur pipette) and dry under N_2 in N-evaporator at 65°.

For gas chromatogram calibration standard, add 1 mg inositol to No. 9826 tube. Add exactly 1 ml acetic anhydride-pyridine (1:1) to each of the dried samples. Cap tightly and heat overnight at 100° C. Cool. For gas chromatographic analysis, inject 1 µl onto 3 percent ECNSS-M (on column) 6-ft column at 180° and 40 ml/min He.

$$\text{Inositol} = \frac{X}{I_c \times W_s};$$

where X = integrator counts/µl injection of sample
I_c = integrator counts/µl injection of inositol calibration solution
W_s = sample weight

Nitrogen compounds

Total nitrogen.—Determine total nitrogen of all three fractions of each sample by the AOAC Kjeldahl method (*6*). Total nitrogen of whole feedlot waste (mg N/g sample, dry basis) is obtained by summing the nitrogen contributed by all three fractions; each fraction's contribution is its total nitrogen content (dry basis) multiplied by its percentage of the total solids in the whole sample.

Total and free amino acids.—Lyophilized samples of the waste fractions were sent to Analytical Biochemistry Laboratories, Inc., Columbia, Mo. Analysis of lyophilized samples generally followed appropriate methodology outlined by Kaiser and others (*30*). Recent advances in esterification and in column packing were also employed according to Gehrke and others (*22, 23*). Modification of the usual cleanup procedure was required. The following procedure was successful.

Procedure: Reflux the lypholized samples with 80 percent EtOH. Filter sample through a glass fiber filter paper and take the extract to dryness on a roto evaporator. Reconstitute dried extract with 10 ml of 0.1 *N* HCl. Place sample solution in an ultrasonic bath about 30 seconds and then refilter through glass fiber filter paper. Pass filtrate through a cation exchange resin for further cleanup. Form the n-butyl-N-trifluoracetyl derivative and do chromatography on a dual column system.

Nonprotein nitrogen.—Analyses were carried out only on the soluble fraction. Ammonia was calculated in a manner similar to total nitrogen. The sum of ammonia plus urea-nitrogen was calculated in a manner similar to total nitrogen; urea-nitrogen was found by difference. AACC methods were employed (*2*).

Nitrate and nitrite are determined by ASTM colorimetric methods (*4, 5*). However, clarification is required to reduce background color and turbidity of samples before analysis. The colorimetric procedures for both ions were satisfactorily applied to samples clarified by the procedure below without further modifications (other than a proportional reduction in volumes of sample and reagents to a

workable level in the case of nitrite method).

Clarification procedure: Place either a 1.5- or 3.0-ml aliquot of the soluble fraction in a 50-ml Erlenmeyer flask. Use 3.0 ml if the dry weight of the soluble fraction is less than 4 percent of its wet weight; use 1.5 ml if the dry weight is 4 percent or more (more dense, fresher samples). Bring the volume in the flask to 15 ml with distilled water. Add 15 ml $Al(OH)_3$ gel (prepared according to ASTM Method D 1254-67 for nitrite ion). Mix, then allow to stand several minutes. Transfer to test tubes and centrifuge at high speed (clinical type centrifuge) 5 min. Pass through Whatman No. 41 paper to remove remaining floating particles. Solutions should now be clear, but may contain a trace of color. Carry a reagent blank through the procedure.

A 5-ml clarified sample was used for both nitrate and nitrite. The weight of sample (dry basis) per 5 ml varied with each sample but usually was 0.01 g or more per 5 ml clarified sample. In the case of nitrate, nitrate-nitrogen can be detected at 0.5 μg, giving rise to a sensitivity of 0.05 mg NO_3-N/g sample, dry basis. With nitrite, 0.02 μg nitrite-nitrogen can be detected giving rise to a sensitivity of 0.002 mg NO_2-N/g sample, dry basis.

Amines.—Samples were adjusted to pH 10 with *N* KOH and extracted with ether. The ether solution was dried with Na_2SO_4. The ether was removed and the sample acetylated. Subsequent analysis of the samples by gas chromatography showed only traces of eluting components that may have been amines. Insignificant quantities of free amines were present.

Lipid

Total lipid on neutralized and dried fractions.—Weigh into a 15-ml centrifuge tube a neutralized portion of each fraction. The solids content should be 0.5 g or greater. Carefully dry the samples at 105° C. Loosen the dried sample from the tube walls and pulverize sample as much as possible with spatula and glass rod. Add 10 ml of chloroform-methanol (3:1) solution, close tube, and mix thoroughly. Mix several times during 24 h. Centrifuge the sample and decant into a clean centrifuge tube. Reduce supernatant volume to about 1 ml at 45° under flowing nitrogen. Extract the centrifuged solids for 1 h with the chloroform-methanol, centrifuge, and combine supernatants; repeat until supernatant is clear. Evaporate the volume of combined supernatants to about 2 ml, quantitatively transfer to a tared vial, and remove the remaining solvent under flowing nitrogen.

Dry at 50° C to constant weight, weigh and calculate total lipid for each fraction.

$$\text{mg neutral lipids/g dry basis} = \frac{\text{wt total lipid in fraction (g)}}{\text{wt of dry sample from fraction (g)}} \times 1{,}000$$

Reported values may be low because the chloroform-methanol solvent does not appear to penetrate the dried particles (no particle softening or swelling was readily noted) and because some color still was observed in the fresh extracting solvent after three or four batch-type extractions. Although more time consuming, long-term continuous extraction may be better than the method used.

Neutral lipid on acidified fractions.—About 10 ml of the undried fraction is weighed into an 18- by 150-mm test tube. The sample is acidified to pH 4 with *N* HCl. About 10 ml diethyl ether is added to the tube, the tube stoppered and shaken thoroughly. Many of the samples form persistent emulsions. Steps taken to attain phase separation were (a) saturation with NaCl, (b) centrifugation, (c) chilling or heating, (d) addition of hexane to the ether, and (e) dilution of the emulsion with ether. After phase separation, the ether is transferred by syringe to a 15-ml centrifuge tube. Repeat extraction until the ether phase is colorless. The combined ether extracts for each sample are evaporated to about 5 ml under flowing nitrogen. Sodium sulfate is added to dry the ether solution. The tube is centrifuged to pack the sulfate and the ether decanted into tared weighing vials. The sulfate is washed with ether until colorless. The combined washings are dried, weighed, and calculated as

$$\text{mg neutral lipids/g dry basis} = 1{,}000 \times \frac{\text{wt of neutral lipid in fraction}}{\text{calculated dry wt of fraction}}$$

Reported values may be low because the emulsified phase was impossible to break completely in some analyses and undoubtedly contained lipid material lost to the analysis. A liquid-liquid concentration may be a more efficient but time consuming method.

Free-fatty acids on acidified fractions.—The weighed quantity of neutral lipids (preceding section) was put into solution in a measured volume of benzene. A measured quantity of this dilution was removed to a clean, dry vial. The benzene was removed by evaporation under nitrogen. After evaporation about 0.2 ml N, O-Bis-(trimethyl)-acetamide (BSA) was added, the vial capped, shaken and warmed briefly to about 40° C.

The sample, 1 µl, was chromatographed by the procedure patterned after Tallent and Kleiman (*44*). The gas chromatographic conditions were column, 20- by ⅛-inch OD 3 percent OV-1 on 80 to 100 m chromosorb w (dual column); column flow, 40 ml/m He; column temperature, 110° C to 320° at 7°/min; detector, dual flame ionization, temperature = 350°; and injector, 350°. After sample injection and after the BSA peaks emerged, peak area integration was initiated. Component identification was made by retention time comparison with standards. The quantity of each component peak was calculated as its area fraction of the total integrated area of the sample.

Gas chromatographic analysis of the neutral lipid fractions showed a significant amount of material eluting between the monoglyceride and the diglyceride peaks. This material, reported as "other" in the neutral lipid analyses, was not identified. It also appeared in the chromatograms of the unsaponified fraction.

Unsaponifiables.—Saponify acidified fractions.

Elemental

Oxidation of samples before analysis.—To measure the desired inorganic constituents, two wet oxidations using two different acid systems were employed. The first system used perchloric-nitric-hydrochloric acids in an open Kjeldahl flask (*29*). Though designed primarily for sulfur, this digest also proved satisfactory in the analysis of calcium, copper, potassium, sodium, and phosphorus. The second method used sulfuric and nitric acids and was designed primarily for the volatile element mercury (*7*). A funnel with side tube, mounted over the oxidation flask, was used to concentrate, then return acids and water, which distilled over. A reflux condenser was mounted above the funnel to prevent losses of volatile elements. Larger quantities of material were more safely oxidized than with the perchloric acid system. Therefore, those elements expected only in trace quantities, as well as those of known high volatility, were measured in the sulfuric-nitric digest because it contained four times the sample weight per unit volume. These included arsenic, lead, mercury, selenium, and boron.

Oxidation procedure with perchloric acid.—Place 0.1 to 0.2 g (dry wt equivalent) of sample into a 100-ml Kjeldahl flask. Add several carborundum chips. Add 2 ml concentrated nitric acid and 1 ml 72 percent perchloric acid. Digest slowly over gas or electric heater to fumes of $HClO_4$. Oxidize an additional hour. Cool. Add 3 ml 6 *N* HCl. Reboil until fumes of $HClO_4$ form. Cool. Dilute sample digest in a graduated mixing cylinder to contain 0.100 g (dry wt) per 20 ml.

Oxidation procedure with sulfuric acid.—Place 1 to 2 g (dry wt equivalent) of sample into 250-ml, flat-bottomed, boiling flask. Add several carborundum chips. Boil to reduce volume to 15 ml or less if required. Cool. Add 10 ml concentrated nitric acid. Attach separatory funnel containing 5 ml concentrated sulfuric acid and reflux condenser. Boil sample several minutes, then add the H_2SO_4 when boiling is smooth. With stopcock open, boil sample briefly to flush funnel, then close stopcock and collect distillate until H_2SO_4 fumes. Maintain oxidizing conditions in the flask by occasional additions of the distillate back into the flask until the digest clears and is no more than pale yellow. Drain distillate back into digest and reflux until most of the NO_2 is evolved. Add 2 ml, 33 percent urea and reflux 10 min. Cool. Rinse funnel with distilled water. Transfer sample to a 100-ml graduated mixing cylinder, filter silica granules out with glass wool plug, and dilute to contain 1 g sample (dry wt) per 50 ml.

Metals determined by atomic absorption spectrophotometry.—Atomic absorption analyses were performed with a Perkin-Elmer Model 303 spectrophotometer equipped with a single-slot burner and with air-acetylene as the burner mixture. The instrumental conditions and method of analysis followed the standard conditions of analysis for each element as set forth in the Perkin-Elmer Methods Manual supplied with the instrument. Optical alignment and burning conditions were optimized for each analysis as described in the manual.

Sodium, potassium, and calcium were measured on a dilution of the perchloric acid digest, which was prepared to a 0.1 g/ml concentration; copper was determined in the more concentrated digest solution. Lead and mercury were measured on the sulfuric-nitric digest by forming an organic complex, extracting with methyl isobutyl ketone, and reading the metal content of this organic solution against standards prepared in the same way.

Chloride.—The mercuric nitrate titrimetric method of Cheng (*17*) was used following partial clarification of the sample by means of an aluminum hydroxide gel. This was checked by spiking several of the samples with known amounts of chloride. Recoveries were complete.

Method: Transfer 7 to 10 ml sample of each fraction to a tared 50-ml Erlenmeyer flask. Use 2 to 3 ml of soluble fraction, except for hog samples which tend to be lower in chloride. Record sample weight. Add approximately an equal amount of $Al(OH)_3$ gel, reweigh and record diluted sample weight. "Fresher" soluble fraction samples will require about twice as much gel for adequate clarification. Mix well, then transfer to test tubes and centrifuge at high speed (clinical type centrifuge) 5 min. Decant supernatant into a tared 100 ml beaker. Record weight of filtrate. Some color and turbidity can be tolerated. Add 95 percent ethanol in the ratio of 1 part sample: 4 parts ethanol. Adjust to pH 3.5 ± 0.2 with dilute HNO_3. Add 10 drops indicator for each 10 ml filtrate. Titrate with standard $Hg(NO_3)_2$, approximately 0.02 N to the red-violet endpoint using a 10 ml microburet.

Compute the sample weight (dry basis) analyzed.

$$\text{mg Cl/g, dry basis} = \frac{(\text{ml titrant})\ (N\ Hg(NO_3)_2)\ (35.45)}{\text{g sample, dry basis}}$$

Although the two methods compared quite well, the Volhard titration method according to the AOAC (*8*) was not used because the unpredictable chloride content required a large number of repeat analyses and the endpoint was difficult to determine in the presence of interfering colors.

Sulfur.—The barium chloranilate method was subject to considerable interference and lack of reproducibility. It was abandoned. A barium sulfate turbidity method (*11*) was simplified and successfully applied with an average error not exceeding ± 10 percent. Three separate low level (10 μg) standards were carried through the oxidation procedure and 90 to 95 percent of each was recovered.

Method: Place a 1 ml aliquot of digest in a test tube and add 11 ml distilled water. Add 1 ml 20 percent $BaCl_2$ in 2 percent HCl (v/v) and mix. Read within 30 min on a suitable spectrophotometer in 5 cm cells at 400 mμ against a reagent blank. Carry 0 to 100 μg of sulfate-sulfur through the above procedure for use as a standard curve.

1 ml digest contains 5 mg sample (dry basis).

$$\text{mg S per g sample (dry basis)} = \frac{\text{micrograms S found}}{\text{5 mg sample}}$$

Phosphorus.—The perchloric acid digest was analyzed by the stannous chloride method (*3*). That method shows interference from some strong oxidizing agents, such as peroxides and nitrates, but moderate amounts of perchlorate can be tolerated, as indicated by a similar method (*12*) which uses perchloric acid as oxidant.

Subtract absorbance caused by reagent blank and obtain micrograms phosphorus found in aliquot analyzed. Determine weight of sample analyzed; there is an 0.10 g sample (dry wt) in 20 ml digest.

$$\text{mg phosphorus per g sample (dry basis)} = \frac{\text{micrograms phosphorus found in aliquot analyzed}}{\text{mg sample analyzed}}$$

Boron.—The colorimetric reagent of choice is 1,1′ dianthrimide because of the lower level of interference from the reagent itself, yielding lower reagent blanks and greater sensitivity. The method of Ellis and others (*20*) was applied to 2.5 ml of the H_2SO_4 digests; an additional oxidation step, described under wet digestion of the sample in the reference, was required to remove interfering nitrates and expell excess water.

Subtract absorbance caused by reagent blank and obtain micrograms boron in 2.5 ml sample from standard curve. 2.5 ml digest contains 50 mg sample (dry basis).

$$\text{mg boron per g sample (dry basis)} = \frac{\text{micrograms boron found}}{\text{50 mg sample}}$$

Arsenic.—Digests prepared under reflux conditions are unsuitable for distillation of arsenic because of retention of H_2S and other compounds containing mercapto groups that complex with arsenic and prevent its distillation (*31*). Therefore, 10 ml of each digest, equivalent to 0.20 g sample, dry basis, was placed in a Kjeldahl flask and boiled to fumes, cooled briefly, 4 drops 30 percent H_2O_2 added and the sample again boiled to fumes. The digests were then diluted to 40 ml and transferred to 250-ml, flat-bottomed, boiling flasks for arsine distillation according to the Food Chemicals Codex procedure (*34*).

Subtract absorbance caused by reagent blank and obtain micrograms arsenic in 10 ml sample from standard curve. A 10-ml digest contains 200 mg sample (dry basis).

$$\text{mg As per g sample (dry basis)} = \frac{\text{micrograms As found}}{\text{200 g sample}}$$

Selenium.—Considerable difficulty was experienced in the determination of selenium by atomic absorption. Selenium was therefore determined colorimetrically by the method of Cheng (*18*). This method is less subject to interference and more sensitive than the atomic absorption method.

Nucleic acids and their components

Separation of nucleic acids from proteins, lipids, and so forth.—Cells in the fiber and particulate fractions were broken by alternate freezing and thawing. The material containing ruptured cells then was lyophilized to obtain a dry sample for

analysis. Place 5 g of sample in chilled (0° C) blender jar with 100 ml 10 percent trichloroacetic acid (TCA). Blend 2 min, two-thirds of time at medium speed, finishing up at full speed.

Transfer slurry to chilled 250-ml polycarbonate centrifuge bottle. Rinse blender jar with 20 ml cold 10 percent TCA and add rinsings to centrifuge bottle. Centrifuge 10 min at 10,000 r/min at 2° C. Decant into a 500-ml Erlenmeyer flask through a loose plug of glass wool. To the residue in the centrifuge bottle add 80 ml of cold 5 percent TCA. Scrape the sediment from the sides with a spatula. Blend until homogeneous with a laboratory stirrer. Centrifuge and decant into the previous extract (Erlenmeyer flask) as in steps above. Repeat residue resuspension using 50 ml of cold 5 percent TCA, centrifugation, and decantation as above. This gives a total extract of about 270 ml. Filter the extract once through a medium glass frit funnel and lyophilize (for determination of purine-pyrimide compounds).

Wash any solids from the frit with 5 to 10 ml of 95 percent ethanol (EtOH) into a 250-ml, glass, centrifuge tube. Transfer all solids from the polycarbonate centrifuge tubes into the glass tubes by using minimal (50 to 75 ml) amounts of 5 percent TCA to wash the solids out. Centrifuge to separate the liquid, which is discarded by decantation.

To the solids add 25 ml EtOH saturated with sodium acetate. Stir with laboratory stirrer until homogeneous. Centrifuge at 2,000 r/min for 15 min. Decant and discard the liquid phase. Repeat solids washing step using the following solvents in order instead of EtOH:acetate: (1) reagent grade acetone; (2) EtOH:$CHCl_3$ (3:1, v/v); (3) repeat (2); (4) EtOH saturated with sodium acetate; (5) EtOH: ether (3:1, v/v); (6) repeat (5); (7) repeat (4); (8) if there is any color in the liquid phase, repeat (5); (9) ether; (10) if there is any color in the ether, repeat (9) and then (4). Dry the solids in air or vacuum. Transfer to weighed vials and weigh. Store in refrigerator in capped vial (for separation of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) from other solids). This extensive extraction removed 16 and 24 percent of soluble materials from the fiber and particulate fractions, respectively, of both the A and AP samples.

Separation of DNA and RNA from other solids.—Weigh 0.25 g of dry sample (from above) into a 15-ml centrifuge tube. Add 4 ml of 0.3 *N* KOH and incubate for 3 h at 37° C. Cool to room temperature. Centrifuge 10 min at 2,000 r/min. Decant the supernatant into another 15-ml centrifuge tube. Wash the residue with 1 ml of 0.03 *N* KOH. Centrifuge for 10 min at 2,000 r/min. Add the supernatant to the first alkaline digest. Repeat wash step. Discard the residue.

Determination of RNA.—The procedure is that of Munro and Fleck (*33*). To the alkaline digest and washings, add 2.5 ml 1.2 *N* $HClO_4$ (PCA). Stir to precipitate DNA. Place tube in ice bath for 10 min. Centrifuge; decant supernatant into a 100-ml volumetric flask. This is the RNA fraction. Wash the residue twice with 5 ml of 0.2 *N* PCA and centrifuge. Decant the washings and add to the RNA fraction. Save any residue for DNA analysis. Add 12 ml 0.6 *N* PCA to the RNA fraction and make up to 100 ml with distilled water. This gives an RNA fraction in 0.1 *N* PCA. Measure the absorbance of this solution at 260 nanometers (nm). Make dilutions as needed. An absorbance of 1 is equal to 32 μg RNA/ml from rat liver or 34.5 μg RNA/ml from yeast. A detection limit of 3.4 mg RNA/g was found for this procedure, which is similar to the results of Munro and Fleck.

Determination of DNA.—The procedure is based on the method of Burton (*15*). To the residue reserved from RNA analysis, add 2 ml water and 2 ml 2 *N* PCA. Heat at 70° C for 15 min in a loosely stoppered tube. Cool to room temperature, using an ice bath. Centrifuge. Pipette 2 ml of the filtrate into a 15-ml glass-stoppered centrifuge tube. Add 2 ml freshly prepared 4 percent diphenylamine in glacial acetic acid. Add 0.1 ml aqueous acetaldehyde. Stopper. Incubate 20 h at 30°. Analyze the sample spectrophotometrically.

To prepare the standard DNA calibration curve, make DNA standard to obtain concentration of 30 mg/100 ml in 5 *M* NaOH; store at 0° C. Make up standards from 0 to 120 μg per 2 ml by combining measured volumes of DNA solution with sufficient 5 *M* NaOH to total 5 ml and add 5 ml 1 *N* perchloric acid to give exactly 10 ml of known DNA concentration. Treat as DNA samples to prepare the standards for the spectrophotometric analysis. Make a calibration curve, plotting the DNA weight in micrograms per 2-ml sample versus corrected absorbance, the absorbance value being absorbance at 593 nm minus absorbance at 700 nm. This should be a linear plot. For spectrophotometric analysis, read the blank (5 *M* NaOH) against H_2O in the reference beam at both 593 and 700 nm in absorbance, read the standards and samples against the blank at both wavelengths, and read off the weight

of DNA in the sample from the calibration curve. Calculate the amount of DNA in the sample as follows:

$$\text{mg DNA/g} = \frac{\text{Micrograms DNA found} \times 2 \times \frac{\text{Initial volume}}{\text{Aliquot of initial volume}}}{\text{g sample wt} \times 1{,}000}$$

Manure samples gave a light yellow color in the final analytical solution, which was not present in the DNA standards or the reagent blank. This was corrected by including a blank which extracted pigments but not DNA from a manure sample. It was prepared by omitting the initial 2 *N* PCA reagent but adding the acetic acid and acetaldehyde to a 2 ml manure sample before continuing with the analysis. This yellow blank was stable and had typical absorbance values of 0.018 at 593 nm and 0.003 at 700 nm, the difference being 0.015. This blank value was used to correct the absorbance readings obtained.

Determination of purine-pyrimidine compounds.—Lyophilized soluble fraction samples and lyophilized TCA extracts of the fiber and particulate fractions after cell rupture were diluted to 0.1 percent aqueous solutions. These preparations were analyzed for total purine-pyrimidine content by ultraviolet absorption spectrophotometry at 260 nm.

Free bases, nucleosides, and nucleotides.—The soluble fractions of the A and AP samples (three collections) were extracted by the following procedure. All reagents and glassware were kept ice cold during the procedure. Weigh 0.12 g (dry basis) of soluble fractions into heavy-walled, 10-ml centrifuge tubes. Dilute to 4.57 ml as required with distilled water at 2° C. Volumes used are based on the solids concentrations of the most dilute sample tested; all extracts ultimately contain 0.01 g sample (dry basis) per ml extract. Add 4.57 ml 0.4 *N* PCA. Mix well. Stand 10 min at 0° to 2°. Centrifuge at 0° to 2° and 15,000 r/min for 15 min. Carefully withdraw 6.86 ml supernatant and place in a 20-ml beaker. Neutralize to pH 6 to 7 by titration with 10 percent KOH (0.77 to 0.84 ml required). Add sufficient distilled water to bring the final volume to 9.0 ml. Mix well, keeping cold. Centrifuge at 0° to 2° and 10,000 r/min for 10 min. Decant supernatant and freeze in several aliquots until ready for analysis.

Standards for analyses were prepared by dissolving 20 mg of each compound in 100 ml distilled water or eluant buffer solution (with a hot water bath for the bases, which dissolved with difficulty). This solution was diluted 1:10 with distilled water or buffer solution to contain 20 ng/μl. Five μl injections corresponded to 100 ng compound. Guanine was particularly insoluble (0.0005 percent or 25 ng/5 μl at saturation). Some standards decomposed rapidly at room temperature under fluorescent lighting. All standards were kept in the dark, and the more soluble nucleosides and nucleotides were kept refrigerated.

Chromatographic conditions were similar to those of Horvath and Lipsky (*25*, *26*). A Perkin-Elmer Liquid Chromatograph, Model 1220, equipped with an Ultraviolet Absorption Detector, Model 250 (254 mμ) and microcell, which provided sensitivities up to 0.01 absorbance in its full scale, was used. The coiled columns were mounted in a jacketed, cylindrical, stainless-steel water bath (Precision Scientific Co.) and heated by an external circulating water bath equipped with an adjustable thermoregulator (P. M. Tamson, N.V., Holland, Type T3-100). A continuous flow, on column, stainless-steel injector (Reeve Angel, 1/8 inch) was securely fastened to the water bath cover. A Teflon needle guide was mounted over the injection port to establish the point of injection just above the column packing.

Prepacked and tested 3 m by 1 mm inside diameter (ID) columns were procured from Reeve Angel, HC Pellionex SCX (pellicular cation) and AS Pellionex SAX (pellicular anion). Stainless-steel capillary tubing conducted the column effluent to the detector. Low dead volume connectors and fittings were used throughout the system. Hamilton No. 701-10 μl syringes with Kel-F guides were used for injecting samples.

Standard chromatographic techniques were used for injection. The low noise levels permitted analysis of the samples near the maximum attenuation (0.02 absorbance units full-scale) for the greatest sensitivity. The attenuation was occasionally reduced to locate the apex of peaks that would have otherwise been off scale. The detection limit of the compounds varied from 1.5 to 100 ng, depending upon their associations with nearby peaks and depending upon their peak heights. As little as 1 to 2 divisions were accepted as the minimum detectable amount in the case of shorter, broader, late-eluting peaks such as adenine. More commonly a deflection of three to five divisions was considered significant. No peaks were found at the uridine location in a valley between the solvent peak and the uracil peak. Reduced attenuation or reduced sample size was necessary to bring this area of the chromatogram on scale. This reduced the detectable amount of uridine to about 50 ng for a sensitivity of 1 mg uridine per g sample.

Peak heights of the standards were essentially proportional to the concentrations of each compound; they were used to obtain quantitative data. Five microliters of extract was usually injected, which contained 0.05 mg or 50 μg of sample (dry basis).

ng compound/μg sample
= mg compound/g sample (dry basis)

Operating conditions used for the analysis of bases were column temperature, 59.5° C; pressure, 700 lb/in²; flow rate, 6 ml/h; attenuation, 0.02 absorbance units full scale (AUFS); eluent buffer, 0.02 *M* KH_2PO_4, pH 5.5 adjusted with 0.1 *M* KOH; column, pellicular cation exchange resin, 3 m by 1 mm ID; extract volume analyzed, 5 μl; analysis time, 60 min.

Operating conditions used for the analysis of nucleosides and uracil were column temperature, 42° C; pressure, 600 lb/in²; flow rate, 4.5 ml/h; attenuation, 0.02 AUFS; eluent buffer, 0.02 *M* KH_2PO_4, pH 5.5 adjusted with 0.1 *M* KOH; column, pellicular cation exchange resin, 3 m by 1 mm ID; extract volume analyzed, 1 or 5 μl; analysis time, 40 min. The detection limit of uridine was severely reduced to about 1 mg/g sample. Improved separation in the uridine area was achieved with standards chromatographed at 30° to 35°. Uracil was also computed from these chromatograms. It was better separated from the nucleosides and the solvent peak under these conditions than under the optimum conditions established for the remainder of the bases.

The nucleotides were separated isocratically in two phases, the first employing a more dilute buffer for the monophosphate nucleotides, and the second employing a stronger buffer for the di- and triphosphate nucleotides. The procedures of Burtis and Gere (*14*) were modified and applied here.

Operating conditions used for the analysis of monophosphate nucleotides were column temperature, 80° C; pressure, 800 lb/in²; flow rate, 24 ml/h; attenuation, 0.02 AUFS; eluent buffer, 0.005 *M* KH_2PO_4, pH 3.3 adjusted with 1:10 H_3PO_4; column, pellicular anion exchange resin, 3 m by 1 mm ID; extract volume analyzed, 5 μl; analysis time, 30 min.

Operating conditions used for the analysis of di- and triphosphate nucleotides were column temperature, 80° C; pressure, 300 lb/in²; flow rate, 9 ml/h; attenuation, 0.02 AUFS; eluent buffer, 0.375 *M* KH_2PO_4, pH 4.05; column, pellicular anion exchange resin, 3 m by 1 mm ID; extract volume.

Results and Discussion

Considering the divergent conditions of the selected feedlots, the composition of the samples was remarkably similar. In general, variability in chemical composition did not correlate with season, geographic site, or feedlot conditions. Only the standard waste analyses showed wide variation. The few detectable differences in composition of cattle feedlot waste, which did correlate with specific feedlot conditions as well as the differences between cattle and hog wastes, are included in the discussion of the specific analyses.

On a dry weight basis, 83 percent of the waste was defined by these analyses. The major factors affecting analyses were errors inherent in the sampling procedure or in sample transport, although minimized as much as was practical. Errors caused by technical difficulties encountered during assay were uniform.

Analysis by fraction—fiber, particulate, and soluble—was accomplished to provide the information required for waste use in developing technologies. Analytical results for each sample together with the average analyses for each feedlot are in tables 2 to 11. Designations correspond to those used for the feedlots in table 1. Seasonal and overall averages for cattle waste and hog waste analyses are in tables 12 and 13. Average analyses of cattle and hog wastes, calculated on whole waste (dry wt) basis are in table 14.

Although the results are included in all subsequent averages, one sample—the spring 1972 sample from Feedlot F—yielded several particularly abnormal results. When compared with the other five samples of hog waste, As and Cu levels were unusually high in all three fractions. Also, in the soluble fraction, values for COD, total Kjeldahl, and ammonia were high although the total amino acid content was low.

Fractionation

The partition of waste into fiber, particulate, and soluble fractions was the most variable result in the analyses. Apparently, changing conditions at individual feedlots contributed to the twofold to threefold variation in the proportion of the whole waste, which partitioned into the three fractions. In a few instances, the waste contained an abnormal distribution of material so that fractionation yielded higher fiber or particulate fractions than expected.

Notwithstanding, the specific composition of each fraction was consistent with only small variation at-

Text continues on page 53.

TABLE 2.--Chemical analyses of waste from cattle Feedlot A

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	674	306	526	502				
Volatile solids	462	691	962	705				
Ash	538	309	308	385				
pH	7.0	6.65	6.15	6.6	7.3	6.3	6.1	6.6
Alkalinity[4]	0	0.6	0.08	0.23				
COD	588	847	867	767	1170	1130	1250	1183
BOD	115	175		145	188	227		208
Nitrogen compounds								
Total Kjeldahl	25.36	33.46	37.31	32.04	61.5	68.5	73.7	67.9
Non-protein								
Urea					0	0.4	0	0.1
Ammonia					31.8	21.9	23.9	25.9
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	0.004	<0.002
Total amino acids	69.6	99.2	104.9	91.2	102.4	162.0	161.8	142.1

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	47.2	64.1	53.5	54.9	42.3	20.8	24.5	29.2	10.5	15.1	22.0	15.9
Carbohydrate												
Total neutral	343	268	246	286	305	194	225	241	70	80	79	76
Glucose	295	242	221	253	267	170	202	213	56	72	72	67
Galactose	14	12	8	11	10	12	7	10	3	4	1	3
Mannose	12	8	4	8	10	4	4	6	5	2	3	3
Xylose	14	6	8	9	12	6	8	9	6	2	3	4
Arabinose	8	-	5	4	6	2	4	4	1	st	t	t
Cellulose	239	202	200	214	141	132	121	131	5	4	8	6
Hemicellulose	48	26	25	33	38	24	23	28	15	8	7	10
Lignin	57	77	73	69	51	59	62	57				
Phytic acid[6]	1.31	1.22	1.12	1.21	0.54	0.57	0.49	0.53	0.25	0.21	0.23	0.23

Total soluble saccharides	4	5	4	4	15	20	22	19	37	33	48	39
Glucose	2	3	2	2	7	8	10	8	22	20	40	27
Oligosaccharides	2	2	2	2	8	12	12	11	15	13	8	12
Nitrogen compounds												
Total Kjeldahl	16.1	24.3	22.5	21.0	26.7	36.2	37.0	33.3	61.5	68.5	73.7	67.9
Total amino acids	51.4	73.0	71.6	65.3	81.6	134.3	126.4	114.1	102.4	162.0	161.8	142.1
Alanine	5.3	11.7	11.7	9.5	8.2	15.9	15.2	13.1	29.2	48.5	48.4	42.0
Valine	3.3	4.3	3.8	3.8	5.5	8.7	7.4	7.2	5.2	8.6	7.6	7.1
Glycine	3.1	5.4	5.8	4.8	5.0	9.1	8.7	7.6	4.3	15.1	16.7	12.0
Isoleucine	2.7	3.5	2.9	3.0	4.9	7.9	6.2	6.3	4.1	7.4	5.8	5.8
Leucine	4.5	6.3	5.4	5.4	7.2	11.5	10.9	9.9	5.2	8.9	8.8	7.6
Proline	3.1	4.5	4.0	3.8	4.1	7.2	7.3	6.2	3.3	5.4	5.9	4.9
Threonine	2.5	2.8	3.1	2.8	3.6	5.5	5.4	4.8	3.4	5.7	6.1	5.1
Serine	2.3	2.3	3.1	2.6	3.1	4.4	5.6	4.3	2.8	3.5	5.7	4.0
Methionine	1.3	1.4	1.3	1.3	2.1	3.1	2.5	2.6	9.3	4.5	3.9	5.9
Hydroxyproline	0.4	0.4	0.6	0.5	0.2	0.3	0.5	0.3	0.3	0.4	0.6	0.4
Phenylalanine	2.3	3.6	3.2	3.0	4.1	7.0	6.4	5.8	3.2	6.3	5.7	5.1
Aspartic acid	4.6	6.1	6.0	5.6	8.1	12.6	11.7	10.8	7.9	12.1	12.0	10.7
Glutamic acid	9.5	11.6	11.6	10.9	15.7	21.8	23.2	20.2	16.5	19.5	19.4	18.5
Tyrosine	1.5	2.0	1.8	1.8	2.6	4.7	4.0	3.8	2.1	4.5	3.7	3.4
Lysine	2.4	3.5	3.5	3.1	4.5	7.8	6.5	6.3	3.6	7.5	7.0	6.0
Histidine	0.8	1.2	1.5	1.2	0.9	2.1	1.4	1.5	0.7	1.5	1.1	1.1
Arginine	1.8	1.9	1.8	1.8	1.7	4.2	2.3	2.7	1.2	2.5	2.6	2.1
Cystine	<0.05	0.3	0.4	0.2	<0.05	0.5	1.4	0.6	<0.05	0.3	0.8	0.4
Free amino acids	5.1	13.1	12.4	10.2	3.6	11.9	10.5	9.7	29.1	58.5	67.8	51.8
Alanine	3.3	7.2	7.0	5.8	2.0	6.2	5.7	4.6	16.3	36.0	38.2	30.2
Valine	0.2	0.5	0.5	0.4	0.2	0.6	0.5	0.4	1.7	1.8	2.7	2.1
Glycine	0.3	1.2	1.7	1.1	0.1	1.1	1.4	0.9	0.4	6.5	9.1	5.3
Isoleucine	0.1	0.3	0.3	0.2	0.1	0.2	0.3	0.2	0.9	1.4	1.9	1.4
Leucine	0.2	0.3	0.4	0.3	0.2	0.4	0.5	0.4	1.3	1.8	2.4	1.8
Proline	0.1	0.3	0.3	0.2	0.1	0.3	0.3	0.2	0.9	1.3	1.7	1.3
Threonine	0.1	0.1	0.2	0.1	<0.05	0.1	0.2	0.1	0.3	0.6	1.2	0.7
Serine	<0.05	0.2	0.1	0.1	<0.05	0.4	0.4	0.3	0.2	0.3	0.8	0.4
Methionine	<0.05	0.3	0.1	0.1	<0.05	0.3	0.1	0.1	0.1	0.4	0.6	0.4
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	0.1	0.1	0.2	0.1
Phenylalanine	0.1	0.3	0.3	0.2	0.1	0.3	0.3	0.2	0.6	1.0	1.2	0.9
Aspartic acid	0.1	0.3	0.4	0.3	0.1	0.4	0.4	0.3	0.6	1.0	1.7	1.1

See footnotes at end of table.

TABLE 2.--Chemical analyses of waste from cattle Feedlot A--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	0.4	0.6	0.6	0.5	0.5	0.8	0.3	0.5	4.8	3.4	3.3	3.8
Tyrosine	0.1	0.2	0.1	0.1	0.1	0.2	<0.05	0.1	0.5	1.0	0.6	0.7
Lysine	0.1	0.1	0.2	0.1	<0.05	0.2	0.1	0.1	0.4	1.3	1.7	1.1
Histidine	0.1	1.0	0.1	0.4	0.1	0.3	<0.05	0.1	<0.05	0.4	0.6	0.3
Arginine	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.1
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	22.0	23.3	50.8	32.0	40.0	45.7	92.7	59.4	369.0	94.4	64.0	175.8
Total neutral	23.0	31.0	16.3	23.6	28.0	40.0	21.9	29.9	57.0	42.5	29.2	42.9
Myristic acid	0.6	0.5		0.6	0.8	0.7		0.8	-	1.0		0.5
Palmitic acid	2.0	2.9		2.4	3.0	3.3		3.2	6.1	4.7		5.4
Stearic acid	9.5	15.0		12.3	14.4	18.2		16.3	22.6	23.1		22.9
Unsaturated C_{18} acids	1.0	0.4		0.7	1.1	1.2		1.2	3.1	1.1		2.1
Glycerides												
Mono-	t	t		t	t	t		t	-	t		t
Di-	1.0	0.5		0.8	t	0.8		0.4	-	0.1		t
Tri-	t	t		t	-	t		t	-	t		t
Other[7]	4.6	9.8		7.2	3.6	14.5		9.0	9.1	8.9		9.0
Unsaponifiable		2.0	1.6	1.8		6.0	2.1	4.0		4.0	3.1	3.6
Elemental												
K (potassium)	8.4	11	8.4	9.3	12	11	11	12	70	48	46	55
Na (sodium)	4.3	5.8	4.8	5.0	4.0	4.6	4.4	4.3	79	31	30	49
Ca (calcium)	21	13	11	15	37	28	25	30	20	28	26	25
Cu (copper)[8]	20	30	90	46	54	70	190	104	22	30	70	41
Pb (lead)[8]	<0.10	<5	<5	<5	<0.18	<5	<5	<5	<0.10	<5	<5	<5
Hg (mercury)[8]	1.0	<20	<20	<20	1	<20	<20	<20	1.5	<20	<20	<20
Cl (chloride)	6.0	9.6	7.3	7.6	5.0	6.5	6.2	5.9	88.0	56.0	51.0	65.0
S (sulfur)	4.6	3.8	2.6	3.6	4.9	4.0	4.5	4.5	28.0	12.8	12.5	17.8
P (phosphorus)	4.4	5.2	4.0	3.6	7.6	9.0	10.0	8.9	4.4	11.4	11.2	9.0
B (boron)[8]	24	28	14	11	35	44	27	35	52	52	40	48
As (arsenic)[8]	3	<1	<1	1	3	<1	<1	1	3	<1	1	1
Se (selenium)[8]		<2	<2	<2		<2	<2	<2		4	2	3

[1]Analyses: mg/g dry wt. of fraction except as noted. [2]Collection time of samples: 1, Summer 1971; 2 Winter 1972; 3, Spring 1972. [3]Total solids: mg/g wet wt. [4]Alkalinity: ml of 1N HCl or NaOH required to neutralize 2 g dry wt. of waste. [5]t = trace quantities. [6]Phytic acid: reported as mg inositol/g dry wt. [7]Other (neutral lipid): unidentified components eluting after the monoglycerides and before the diglycerides. [8]Cu, Pb, Hg, B, As, Se: µg/g dry wt.

TABLE 3.—Chemical analyses of pristine (fresh) waste from cattle Feedlot A - AP samples

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	271	229	227	242				
Volatile solids	742	780	885	802				
Ash	258	220	115	198				
pH	5.45	6.0	5.95	5.8	5.55	5.9	5.9	5.8
Alkalinity[4]	0.36	0.20	0.18	0.25				
COD	878	948	958	928	1530	1340	1500	1460
BOD	260	260		260	302	222		262
Nitrogen compounds								
Total Kjeldahl	28.73	34.34	32.68	31.92	46.8	61.0	60.7	56.2
Non-protein								
Urea					0.2	0.2	0.4	0.3
Ammonia					9.6	10.0	4.6	8.1
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	0.002	<0.002
Total amino acids	115.4	115.1	118.5	116.3	156.2	201.6	187.9	181.9

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	51.5	70.0	64.9	62.1	31.2	15.5	13.2	20.0	17.3	14.5	21.9	17.9
Carbohydrate												
Total neutral	307	265	276	273	232	284	255	257	105	72	88	88
Glucose	255	238	247	247	198	246	235	226	84	60	80	75
Glactose	13	9	10	11	8	10	7	8	4	2	3	3
Mannose	13	6	8	9	9	8	6	8	7	6	2	5
Xylose	17	8	8	11	12	12	4	9	8	4	2	5
Arabinose	9	4	3	5	5	8	3	5	2	-	1	1
Cellulose	201	184	234	206	122	102	142	122	3	6	12	7
Hemicellulose	52	27	29	36	34	38	20	31	21	12	9	14
Lignin	71	56	41	56	43	46	35	41				
Phytic acid[6]	1.25	1.18	1.00	1.14	0.56	0.52	0.49	0.52	0.25	0.22	0.21	0.23

See footnotes at end of table 2.

TABLE 3.--Chemical analyses of pristine (fresh) waste from cattle Feedlot A - AP samples--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	3	5	7	5	16	18	16	17	40	41	48	43
Glucose	2	2	4	3	9	8	6	8	20	26	38	28
Oligosaccharides	1	3	3	2	7	10	10	9	20	15	10	15
Nitrogen compounds												
Total Kjeldahl	22.2	28.7	22.0	24.3	29.6	34.8	38.6	34.3	46.8	61.0	60.7	56.2
Total amino acids	87.2	91.0	87.0	88.4	139.4	143.5	157.7	146.9	156.2	201.6	187.9	181.9
Alanine	10.6	10.1	7.1	9.3	14.4	15.1	11.7	13.7	29.3	26.8	17.4	24.5
Valine	5.3	6.2	5.0	5.5	8.6	9.3	8.8	8.9	9.2	13.4	10.7	11.1
Glycine	5.1	5.9	5.0	5.3	8.2	9.2	8.2	8.5	10.2	14.4	11.8	12.1
Isoleucine	4.5	4.7	3.7	4.3	7.5	7.7	7.2	7.5	8.2	11.1	9.1	9.5
Leucine	7.9	7.9	7.4	7.7	12.3	12.9	13.2	12.8	10.4	14.9	13.8	13.0
Proline	5.5	5.1	5.1	5.2	8.2	8.1	9.0	8.4	6.1	8.7	7.4	7.4
Threonine	3.9	4.5	4.3	4.2	6.2	6.9	6.7	6.6	7.5	10.9	9.2	9.2
Serine	3.4	3.4	3.8	3.5	5.4	5.2	6.2	5.6	5.6	6.5	8.4	6.8
Methionine	1.9	1.9	1.6	1.8	3.1	3.2	3.2	3.2	5.1	4.5	0.9	3.5
Hydroxyproline	0.4	0.5	0.7	0.5	0.3	0.3	0.3	0.3	<0.05	<0.05	3.0	1.0
Phenylalanine	4.3	5.1	4.3	4.6	7.2	7.7	7.3	7.4	6.9	10.5	8.6	8.7
Aspartic acid	7.5	8.8	7.8	8.0	12.8	14.0	13.5	13.4	14.4	19.8	18.0	17.4
Glutamic acid	15.6	14.0	18.2	15.9	24.4	23.3	39.3	29.0	24.0	29.1	38.9	30.7
Tyrosine	2.7	3.1	3.0	2.9	5.0	5.2	5.8	5.3	5.2	8.1	7.9	7.1
Lysine	4.3	5.0	4.2	4.5	7.9	8.2	7.6	7.9	8.5	12.0	11.5	10.7
Histidine	1.4	2.2	2.0	1.9	2.7	2.9	3.4	3.0	2.1	5.6	4.4	4.0
Arginine	2.9	2.6	3.0	2.8	5.2	3.7	5.0	4.6	3.6	3.7	5.2	4.2
Cystine	<0.05	<0.05	0.6	0.2	<0.05	0.5	1.3	0.6	<0.05	1.3	1.5	0.9
Free amino acids	6.4	6.3	5.4	6.0	5.4	7.9	6.9	6.7	23.6	21.3	7.7	17.5
Alanine	3.8	2.9	1.6	2.8	3.0	3.6	1.7	2.7	14.7	9.9	2.5	9.0
Valine	0.2	0.4	0.4	0.3	0.2	0.5	0.5	0.4	1.1	1.1	0.5	0.9
Glycine	0.4	0.6	0.4	0.5	0.3	0.8	0.5	0.5	1.4	2.4	0.6	1.5
Isoleucine	0.1	0.1	0.4	0.2	0.2	0.2	0.4	0.3	0.8	0.7	0.5	0.7
Leucine	0.2	0.1	0.3	0.2	0.2	0.1	0.4	0.2	1.1	0.5	0.5	0.7
Proline	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.8	0.4	0.5

Threonine	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.7	0.3	0.4
Serine	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3
Methionine	0.1	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	<0.05	0.1
Phenylalanine	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.6	0.6	0.3	0.5
Aspartic acid	0.1	0.1	0.1	0.1	<0.05	0.1	0.2	0.1	0.1	0.2	0.1	0.1
Glutamic acid	0.4	0.6	0.6	0.5	0.3	0.7	0.7	0.6	1.1	2.0	0.7	1.3
Tyrosine	0.2	0.2	0.2	0.3	0.2	0.2	0.5	0.3	0.6	0.7	0.3	0.5
Lysine	0.1	0.2	0.3	0.2	0.1	0.2	0.4	0.2	0.7	0.9	0.4	0.7
Histidine	<0.05	0.3	<0.05	0.1	<0.05	0.2	0.1	0.1	0.1	0.2	<0.05	0.1
Arginine	<0.05	<0.05	0.2	0.1	0.2	0.1	0.3	0.2	0.1	0.1	<0.05	0.1
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	73	40.1	191.5	101.5	60	53.2	195.2	102.8	161	133.0	327.4	207.1
Total neutral	42	47.8	18.8	36.2	80	36.0	34.1	50.0	36	43.7	19.6	33.1
Myristic acid	1.1	0.8		1.0	2.3	0.6		1.5	t	0.6		0.3
Palmitic acid	4.7	4.2		4.4	8.8	3.5		6.2	8.0	4.4		6.2
Stearic acid	17.7	22.3		20.0	39.8	18.1		29.0	40.2	22.1		31.2
Unsaturated C_{18} acids	1.5	1.2		1.4	2.5	1.1		1.8	2.3	1.0		1.7
Glycerides												
Mono-	t	t		t	t	t		t	t	t		t
Di-	t	1.1		0.6	t	0.7		0.4	t	0.8		0.4
Tri-	t	t		t	t	t		t	t	t		t
Other[7]	4.2	14.4		9.3	7.0	9.3		8.2	7.2	11.1		9.2
Unsaponifiable		8	1.5	4.8		4	2.0	3.0		3	2.4	2.7
Elemental												
K (potassium)	12	9.6	4.0	8.5	8.8	9.6	5.4	7.9	3.8	30	14	15.9
Na (sodium)	57	3.4	1.6	20.7	3.8	2.6	1.8	2.7	17	10	7.2	11.4
Ca (calcium)	11	12	8.5	10.5	17	18	21	19	20	20	21	20
Cu (copper)[8]	60	40	30	43	76	70	110	85	34	60	60	51
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	2	<20	<20	<20	1.5	<20	<20	<20	2	<20	<20	<20
Cl (chloride)	6.4	5.9	2.5	4.9	4.1	4.5	2.2	3.6	32	22	10.3	21.4
S (sulfur)	4.8	3.2	1.7	3.2	4.5	3.5	3.3	3.8	11.0	6.8	3.4	7.1
P (phosphorus)	5.8	7.2	4.0	5.7	7.8	8.1	10.0	8.6	18.6	14.8	13.2	15.5
B (boron)[8]	16	16	6	13	17	30	10	19	28	15	11	18
As (arsenic)[8]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Se (selenium)[8]		<2	<2	<2		<2	<2	<2		<2	<2	<2

See footnotes at end of table 2.

TABLE 4.--Chemical analyses of waste from cattle Feedlot B

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	684	632	836	717				
Volatile solids	737	737	737	737				
Ash	263	263	263	263				
pH	7.25	7.65	7.2	7.35	7.85	7.35	7.25	7.5
Alkalinity[4]	0.90	0.13	0.11	0.38				
COD	597	762	815	725	923	1020	908	950
BOD	90	125		108	233	319		276
Nitrogen compounds								
Total Kjeldahl	31.78	30.35	28.29	30.14	42.1	48.2	45.5	45.3
Non-protein								
Urea					0.7	0.5	0	0.4
Ammonia					14	20.1	11.6	13.4
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	0.004	0.016	0.007
Total amino acids	112.3	107.9	115.3	111.8	78.5	82.7	87.6	82.9

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	73.3	55.7	56.6	61.9	17.7	35.2	34.8	29.2	9.0	9.1	8.6	8.9
Carbohydrate												
Total neutral	332	331	335	333	234	305	215	251	83	81	93	85.6
Glucose	289	304	300	298	200	280	190	223	68	72	91	77
Galactose	11	13	12	12	11	9	10	10	5	2	[5]t	2
Mannose	10	6	10	9	10	6	6	7	6	3	t	3
Xylose	15	6	7	9	9	6	5	7	3	2	2	2
Arabinose	7	2	6	5	4	4	4	4	1	2	t	1
Cellulose	166	226	260	217	141	147	138	142	4	6	8	6
Hemicellulose	43	27	35	35	34	25	25	28	15	9	2	9
Lignin	188	148	142	159	140	132	108	127				
Phytic acid[6]	1.52	1.31	1.09	1.21	0.51	0.48	0.53	0.51	0.22	0.21	0.22	0.22

Total soluble saccharide	3	7	8	6	17	15	20	17	30	41	36	36
Glucose	1	4	4	3	5	8	12	8	18	29	28	25
Oligosaccharides	2	3	4	3	12	7	8	9	12	12	8	11
Nitrogen compounds												
Total Kjeldahl	26.5	21.6	20.3	22.8	48.2	39.6	37.0	41.6	42.1	48.2	45.5	45.3
Total amino acids	97.3	82.7	92.0	90.7	191.6	154.4	160.0	168.7	78.5	82.7	87.6	82.9
Alanine	8.8	7.1	7.6	7.8	18.1	13.6	14.0	15.2	16.0	19.7	11.6	15.8
Valine	5.9	4.9	5.3	5.3	12.0	9.4	8.7	10.0	4.3	4.9	5.3	4.8
Glycine	5.1	4.4	4.8	4.8	9.7	7.9	7.6	8.4	4.1	4.1	7.1	5.1
Isoleucine	4.6	3.8	4.1	4.2	9.7	7.7	6.9	8.1	3.5	3.8	3.8	3.7
Leucine	9.6	7.9	9.0	8.8	19.3	15.9	16.4	17.2	5.5	5.3	5.9	5.6
Proline	6.7	5.5	6.4	6.2	12.1	10.4	10.9	11.3	2.6	3.2	4.8	3.5
Threonine	4.3	3.4	3.8	3.8	8.1	5.7	6.0	6.6	3.6	3.9	4.5	4.0
Serine	4.1	3.1	3.9	3.7	6.7	5.1	6.1	5.9	2.9	1.9	3.4	2.7
Methionine	1.6	2.0	1.4	1.6	3.7	3.5	2.6	3.3	2.6	2.2	3.3	2.7
Hydroxyproline	1.4	1.3	1.3	1.3	0.8	0.8	0.9	0.8	<0.05	<0.05	0.6	0.2
Phenylalanine	5.0	4.5	4.5	4.6	9.6	8.3	7.8	8.6	3.1	3.7	3.2	3.3
Aspartic acid	9.1	7.5	7.8	8.1	18.1	13.4	12.9	14.8	9.1	9.1	9.4	9.2
Glutamic acid	19.4	16.6	20.4	18.8	38.9	34.1	38.7	37.2	12.5	12.9	16.9	14.1
Tyrosine	2.7	2.4	2.6	2.6	6.3	5.1	5.3	5.6	2.2	2.8	2.7	2.6
Lysine	3.8	3.6	3.5	3.6	7.9	6.0	5.9	6.6	3.3	3.5	2.6	3.1
Histidine	1.9	2.2	1.8	1.9	4.1	2.6	3.2	3.3	1.4	0.7	0.8	1.0
Arginine	3.2	2.4	3.0	2.9	6.1	4.4	4.4	4.9	1.7	1.0	1.4	1.4
Cystine	0.2	<0.05	0.7	0.3	0.4	0.6	1.7	0.9	<0.05	<0.05	0.2	0.1
Free amino acids	0.9	1.1	3.0	1.6	0.6	1.0	3.9	1.8	9.8	20.9	26.5	19.1
Alanine	0.4	0.5	0.7	0.5	0.2	0.3	0.9	0.5	7.8	12.4	5.5	8.6
Valine	<0.05	0.1	0.3	0.1	<0.05	0.1	0.4	0.2	0.2	1.1	2.1	1.1
Glycine	<0.05	<0.05	0.1	0.05	<0.05	0.1	0.2	0.1	0.1	0.3	1.6	0.7
Isoleucine	0.1	<0.05	0.2	0.1	0.2	0.1	0.3	0.2	0.7	0.8	1.6	1.0
Leucine	<0.05	<0.05	0.3	0.1	<0.05	<0.05	0.4	0.1	0.1	0.8	1.8	0.9
Proline	<0.05	<0.05	0.2	0.05	<0.05	<0.05	0.2	0.05	0.1	0.7	1.5	0.8
Threonine	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	0.3	1.1	0.5
Serine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.2	0.1	0.8	0.4
Methionine	0.2	<0.05	0.2	0.1	<0.05	<0.05	0.2	0.05	0.1	0.1	0.4	0.2
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.1	0.05
Phenylalanine	<0.05	0.1	0.2	0.1	<0.05	<0.05	0.2	0.05	<0.05	0.4	0.9	0.4
Aspartic acid	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.1	<0.05	0.2	0.8	2.1	1.0

See footnotes at end of table 2.

TABLE 4.--Chemical analyses of waste from cattle Feedlot B--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	0.1	0.3	0.5	0.3	0.1	0.5	0.6	0.4	0.2	1.8	5.5	2.5
Tyrosine	<0.05	<0.05	0.2	0.05	<0.05	0.1	0.2	0.1	<0.05	0.5	1.0	0.5
Lysine	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.05	<0.05	0.3	0.4	0.2
Histidine	<0.05	0.1	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.4	0.1	0.2
Arginine	0.1	<0.05	<0.05	0.05	0.1	<0.05	<0.05	0.05	0.1	<0.05	0.1	0.05
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	34	32.2	27.4	31.2	57	92.1	142.1	97.1	160	42.8	414.8	334.3
Total neutral	31	28.3	27.9	29.0	38	25.1	18.9	27.3	38	33.0	32.9	34.6
Myristic acid	0.6	0.4		0.5	0.9	0.3		0.6	t	0.6		0.3
Palmitic acid	5.3	5.7		5.5	6.4	5.3		5.8	8.8	5.0		6.9
Stearic acid	15.4	14.1		14.8	17.6	12.0		14.8	22.8	15.6		19.2
Unsaturated C_{18} acids	2.0	1.0		1.5	2.1	1.0		1.6	t	1.0		0.5
Glycerides												
Mono-	t	-		t	t	-		t	-	-		-
Di-	t	0.5		0.2	t	0.5		0.2	-	0.5		0.2
Tri-	-	-		-	t	0.6		0.3	-	0.2		0.1
Other[7]	5.1	4.8		5.0	2.3	4.0		3.2	-	7.3		3.6
Unsaponifiable		3	1.9	2.4		6	2.9	4.4		5	1.9	3.4
Elemental												
K (potassium)	16	11	9.0	12	10	12	11	11	144	120	120	128
Na (sodium)	8.2	6	5.2	6.5	5.9	5.8	5.2	5.6	78	92	84	85
Ca (calcium)	20	16	14	17	30	31	32	31	11	15	12	13
Cu (copper)[8]	8	30	30	26	24	50	50	41	28	20	30	26
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	1	<20	<20	<20	1	<20	<20	<20	1	<20	<20	<20
Cl (chloride)	9.8	9.2	7.6	8.9	7.9	8.3	7.1	7.8	174	201	186	187
S (sulfur)	4.1	2.8	1.9	2.9	19.7	2.8	3.1	8.5	12.1	9.8	7.3	9.7
P (phosphorus)	5.2	4.8	3.2	4.4	8.6	10.6	10.0	9.7	5.8	5.2	4.8	5.3
B (boron)[8]	34	36	16	29	33	32	18	28	31	40	25	32
As (arsenic)[8]	<1	<1	<1	<1	<1	<1	<1	<1	1	1	2	1
Se (selenium)[8]		4	<2	2		<2	<2	<2		<2	4	2

See footnotes at end of table 2.

TABLE 5.--Chemical analyses of waste from cattle Feedlot C

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	680	582	884	715				
Volatile solids	723	652	667	681				
Ash	277	348	333	319				
pH	7.35	8.0	7.35	7.55	7.25	7.85	7.4	7.55
Alkalinity[4]	0.90	0.23	0.14	0.42				
COD	660	1150	830	880	1000	1010	923	978
BOD	100	145		122	203	140		172
Nitrogen compounds								
Total Kjeldahl	35.04	34.18	33.20	34.14	50.2	44.0	42.3	45.5
Non-protein								
Urea					0.5	0.2	0	0.2
Ammonia					13.0	10.4	10.8	11.4
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	0.010	0.003
Total amino acids	124.3	128.8	121.2	124.8	112.7	105.4	82.7	100.3

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	63.0	63.3	63.5	63.3	23.1	24.5	24.8	24.2	13.6	12.2	11.7	12.5
Carbohydrate												
Total neutral	473	361	385	406	198	222	304	241	73	90	88	84
Glucose	417	330	354	367	173	200	281	218	65	80	82	76
Galactose	12	15	12	13	7	10	8	8	3	5	1	3
Mannose	18	8	6	11	7	6	3	5	4	2	1	2
Xylose	18	6	7	10	9	5	6	7	1	2	2	2
Arabinose	8	2	6	5	2	1	6	3	[5]t	1	2	1
Cellulose	244	191	287	241	165	112	151	143	3	5	10	6
Hemicellulose	56	31	31	39	26	22	23	24	8	10	6	8
Lignin	109	110	117	112	61	73	86	73				
Phytic acid[6]	1.34	1.40	1.10	1.28	0.52	0.69	0.45	0.55	0.26	0.22	0.21	0.23

See footnotes at end of table 2.

TABLE 5.--Chemical analyses of waste from cattle Feedlot C--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	4	8	7	6	14	18	18	17	40	40	38	39
Glucose	2	2	4	3	6	6	10	7	22	22	26	23
Oligosaccharides	2	6	3	4	8	12	8	9	18	18	12	16
Nitrogen compounds												
Total Kjeldahl	27.5	25.4	26.1	26.3	46.9	51.9	47.1	48.6	50.2	44.0	42.3	45.5
Total amino acids	104.6	99.2	106.1	103.3	185.3	216.9	178.0	193.4	112.7	105.4	82.7	100.3
Alanine	9.6	8.6	9.2	9.1	16.9	20.1	15.9	17.6	19.6	9.5	14.1	14.4
Valine	6.5	6.2	6.1	6.3	11.8	13.4	9.9	11.7	6.7	6.7	4.8	6.1
Glycine	6.7	5.6	5.4	5.9	10.6	11.1	8.6	10.1	7.0	6.7	5.7	6.5
Isoleucine	5.4	5.2	5.1	5.2	9.9	12.0	8.4	10.1	5.0	5.6	3.8	4.8
Leucine	9.9	10.3	10.4	10.2	18.5	22.9	18.0	19.8	7.2	8.4	5.1	6.9
Proline	6.5	6.0	6.7	6.4	10.5	12.2	10.6	11.1	4.4	4.0	3.4	3.9
Threonine	4.2	4.4	4.4	4.3	7.6	8.5	6.8	7.6	4.5	5.6	3.7	4.6
Serine	4.2	3.6	4.5	4.1	7.0	6.8	6.9	6.9	4.0	3.7	3.1	3.7
Methionine	1.7	2.0	1.9	1.9	3.2	4.7	3.2	3.7	3.2	2.6	5.4	3.7
Hydroxyproline	0.6	0.7	0.7	0.7	<0.05	0.4	0.6	0.3	0.5	0.2	0.4	0.4
Phenylalanine	4.9	5.7	5.4	5.3	9.2	12.1	9.2	10.2	3.8	6.4	2.9	4.3
Aspartic acid	9.7	9.7	9.2	9.5	18.0	20.1	15.1	17.7	12.1	13.9	9.3	11.7
Glutamic acid	21.2	20.4	23.7	21.8	39.0	47.0	42.3	42.8	20.5	17.8	14.2	17.5
Tyrosine	3.3	2.6	3.0	2.9	6.9	7.1	6.0	6.6	4.9	4.0	2.2	3.7
Lysine	4.2	4.3	3.9	4.1	8.1	9.2	6.6	7.9	4.6	5.9	2.9	4.5
Histidine	2.5	1.5	1.9	1.9	3.0	3.7	2.7	3.1	3.1	2.1	0.5	1.9
Arginine	3.2	2.4	3.6	3.0	4.8	5.5	5.9	5.4	1.6	2.3	1.4	1.8
Cystine	0.3	0.1	1.1	0.5	0.5	<0.05	1.2	0.6	<0.05	<0.05	<0.05	<0.05
Free amino acids	3.7	0.6	3.3	2.5	3.8	1.7	4.5	3.3	23.8	4.8	26.3	18.3
Alanine	1.5	0.1	0.1	0.6	1.4	0.2	1.2	0.9	8.6	0.3	6.8	5.2
Valine	0.3	<0.05	0.3	0.2	0.4	<0.05	0.3	0.2	1.6	0.3	1.4	1.1
Glycine	0.1	<0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	1.0	0.5
Isoleucine	0.2	<0.05	0.3	0.2	0.3	0.1	0.3	0.2	1.4	0.2	1.3	1.0
Leucine	0.2	<0.05	0.3	0.2	0.2	<0.05	0.3	0.2	1.3	0.2	1.4	1.0
Proline	0.2	<0.05	0.2	0.1	0.1	<0.05	0.1	0.05	0.7	<0.05	0.8	0.5

Threonine	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.1	<0.05	0.5	<0.05	0.6	0.4
Serine	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.1	<0.05	0.2	<0.05	0.5	0.2
Methionine	<0.05	<0.05	0.4	0.1	0.1	<0.05	0.5	0.2	0.3	0.1	2.6	1.0
Hydroxyproline	0.1	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05
Phenylalanine	0.1	<0.05	0.2	0.1	0.1	<0.05	0.2	0.1	0.6	0.1	0.5	0.4
Aspartic acid	0.1	<0.05	0.2	0.1	0.1	0.1	0.2	0.1	0.8	0.2	1.6	0.9
Glutamic acid	0.7	0.5	0.7	0.6	0.8	0.8	0.8	0.8	5.2	3.0	5.1	4.4
Tyrosine	0.2	<0.05	0.2	0.1	0.1	<0.05	0.2	0.1	0.8	0.1	0.9	0.6
Lysine	0.1	<0.05	0.1	0.05	<0.05	<0.05	0.1	<0.05	0.5	0.1	0.3	0.3
Histidine	<0.05	<0.05	<0.05	<0.05	0.1	0.5	<0.05	0.2	0.9	0.2	1.0	0.7
Arginine	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.3	0.1
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	40	20.0	51.0	37.0	72	50.1	201.6	107.9	231	40.1	389.0	220.0
Total neutral	33	13.1	13.6	19.9	53	43.8	24.3	40.4	39	35.3	35.1	36.5
Myristic acid	0.5	0.2		0.4	1.4	0.6		1.0	1.7	0.7		1.2
Palmitic acid	4.9	2.0		3.4	8.3	6.4		7.4	5.1	4.9		5.0
Stearic acid	12.3	6.6		9.5	21.0	19.0		20.0	12.3	13.7		13.0
Unsaturated C_{18} acids	1.8	0.5		1.2	3.0	1.3		2.2	2.2	1.5		1.8
Glycerides												
Mono-	t	-		t	t	-		t	-	-		-
Di-	-	t		t	t	1.0		0.5	-	-		-
Tri-	-	-		-	-	t		t	-	-		-
Other[7]	5.2	2.7		4.0	8.9	12.6		10.8	2.2	10.8		6.5
Unsaponifiable		2	1.7	1.8		8	3.7	5.8		8	4.9	6.4
Elemental												
K (potassium)	18	16	29	21	16	21	19	19	94	120	150	121.3
Na (sodium)	8.7	5.2	4.8	6.2	6.6	6.0	5.6	6.1	57	48	60	55
Ca (calcium)	17	16	16	16	35	38	34	36	16	14	11	14
Cu (copper)[8]	20	30	30	27	54	50	80	61	48	30	30	36
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	0.7	<20	<20	<20	0.7	<20	<20	<20	0.9	<20	<20	<20
Cl (chloride)	12.8	10.0	7.4	10.1	9.4	9.8	6.9	8.7	122	132	153	136
S (sulfur)	4.4	3.4	3.3	3.7	5.5	4.0	5.3	4.9	17.3	15.6	14.9	15.9
P (phosphorus)	6.8	5.8	6.0	6.2	15.8	13.4	16.0	15.1	7.4	5.0	3.6	5.3
B (boron)[8]	54	52	29	45	34	48	37	39	59	80	72	70
As (arsenic)[8]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	1
Se (selenium)[8]		4	<2	2		<2	3	2		<2	5	2

See footnotes at end of table 2.

TABLE 6.--Chemical analyses of waste from cattle Feedlot D

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	474	304	507	428				
Volatile solids	672	753	628	684				
Ash	328	247	372	315				
pH	7.0	6.85	6.55	6.8	6.9	6.65	6.6	6.7
Alkalinity[4]	0	0.40	0.01	0.13				
COD	801	1010	794	882	1165	1280	1110	1185
BOD	120	175		147	217	231		224
Nitrogen compounds								
Total Kjeldahl	27.21	37.67	31.43	32.10	49.7	62.5	64.1	58.7
Non-protein								
Urea					0.5	1.3	0	0.6
Ammonia					11.9	16.1	16.6	14.8
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	0.005	0.002
Total amino acids	97.8	111.2	115.7	108.2	131.3	166.2	187.5	161.7

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	54.0	53.6	51.3	52.9	32.8	28.6	28.8	30.1	13.2	17.8	19.9	16.9
Carbohydrate												
Total neutral	388	326	344	352	264	274	303	280	56	69	81	68
Glucose	347	295	302	314	244	258	274	258	52	56	72	60
Galactose	10	14	14	12	9	9	10	9	2	6	2	3
Mannose	13	7	8	9	7	4	7	6	2	3	2	2
Xylose	14	7	10	10	3	3	8	5	[5]t	3	4	2
Arabinose	4	3	8	5	1	t	4	2	t	1	1	1
Cellulose	217	231	226	224	149	129	132	136	4	5	12	7
Hemicellulose	41	31	40	37	20	16	29	21	4	13	9	8
Lignin	94	58	68	73	72	46	54	57				
Phytic acid[6]	1.44	1.36	1.10	1.30	0.72	0.50	0.45	0.55	0.17	0.25	0.22	0.21

Total soluble saccharides	3	8	12	7	18	8	21	15	32	46	41	39
Glucose	2	4	5	3	9	4	12	8	18	28	30	25
Oligosaccharides	1	4	4	3	9	4	9	7	14	18	11	14
Nitrogen compounds												
Total Kjeldahl	19.3	31.8	18.1	23.1	31.2	33.2	32.6	32.3	49.7	62.5	64.1	58.7
Total amino acids	72.9	83.6	77.8	78.1	125.4	128.7	133.8	129.3	131.3	166.2	187.5	161.7
Alanine	7.1	13.3	16.8	12.4	11.6	17.7	20.2	16.5	18.4	45.9	92.5	62.3
Valine	4.8	5.2	4.1	4.7	7.8	7.6	7.9	7.7	8.0	9.0	7.0	8.0
Glycine	4.5	5.1	4.1	4.6	7.3	7.3	7.1	7.2	8.6	10.0	7.0	8.5
Isoleucine	4.0	3.9	3.0	3.6	6.8	6.5	6.2	6.5	6.3	7.7	5.5	6.5
Leucine	6.5	7.2	6.0	6.6	11.5	11.9	13.2	12.2	9.9	10.2	8.1	9.4
Proline	4.1	4.3	4.1	4.2	6.8	6.8	6.8	6.8	5.0	4.7	4.3	4.6
Threonine	3.1	3.2	3.2	3.2	5.2	4.9	5.9	5.3	6.3	6.3	5.0	5.9
Serine	2.8	2.8	3.2	2.9	4.7	4.0	5.6	4.8	5.1	4.2	4.6	4.6
Methionine	1.7	1.9	1.4	1.7	2.3	3.0	2.0	2.4	4.0	4.5	5.2	4.6
Hydroxyproline	0.6	0.8	0.8	0.7	0.5	0.6	0.8	0.6	<0.05	0.6	0.6	0.4
Phenylalanine	3.6	4.3	3.3	3.7	6.5	6.6	7.2	6.8	6.4	7.1	5.1	6.2
Aspartic acid	7.0	7.2	6.3	6.8	12.1	11.1	12.4	11.9	13.5	14.1	11.5	13.0
Glutamic acid	14.0	14.6	12.3	13.6	26.2	24.9	21.7	24.3	23.0	22.5	17.0	20.8
Tyrosine	2.0	2.4	2.1	2.2	4.1	4.2	5.1	4.5	4.9	5.2	4.0	4.7
Lysine	3.5	3.6	3.2	3.4	6.6	6.2	6.7	6.5	7.3	7.6	6.1	7.0
Histidine	1.1	1.5	1.2	1.3	2.1	1.9	1.5	1.8	1.0	3.3	1.0	1.7
Arginine	2.3	2.2	2.0	2.2	3.0	2.9	2.9	2.9	3.4	3.3	2.3	3.0
Cystine	<0.05	<0.05	0.7	0.2	0.3	0.5	0.7	0.5	<0.05	<0.05	0.5	0.2
Free amino acids	2.8	8.3	14.6	8.6	1.9	9.0	11.5	7.5	16.8	36.5	69.0	40.8
Alanine	1.6	6.2	11.3	6.4	1.2	6.4	8.1	6.2	7.4	24.4	54.4	28.7
Valine	0.2	0.3	0.3	0.3	0.2	0.4	0.4	0.3	1.1	1.2	1.5	1.3
Glycine	<0.05	0.5	0.2	0.2	<0.05	0.4	0.2	0.2	0.4	2.0	1.1	1.1
Isoleucine	0.1	0.1	0.3	0.2	0.1	0.2	0.3	0.2	0.8	0.7	0.9	0.7
Leucine	0.1	0.2	0.3	0.2	0.1	0.3	0.4	0.3	0.9	1.1	1.2	1.1
Proline	<0.05	0.1	0.2	0.1	<0.05	0.1	0.2	0.1	0.6	0.4	0.7	0.6
Threonine	<0.05	<0.05	0.1	<0.05	<0.05	0.1	0.1	0.05	0.3	0.3	0.3	0.3
Serine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.2	0.6	0.3	0.4
Methionine	0.1	<0.05	0.5	0.2	<0.05	0.1	<0.05	<0.05	0.4	0.2	0.2	0.3
Hydroxyproline	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.05
Phenylalanine	0.1	0.1	0.2	0.1	<0.05	0.2	0.2	0.1	0.5	0.6	0.5	0.5
Aspartic acid	0.1	0.2	0.3	0.2	<0.05	0.1	0.3	0.1	0.2	0.9	1.3	0.8

See footnotes at end of table 2.

TABLE 6.--Chemical analyses of waste from cattle Feedlot D--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	0.4	0.4	0.6	0.5	0.3	0.4	0.7	0.5	2.5	2.2	3.3	2.6
Tyrosine	0.1	0.2	0.2	0.2	<0.05	0.1	0.3	0.1	0.6	0.7	0.8	0.7
Lysine	0.1	0.1	0.1	0.1	<0.05	0.1	0.1	0.05	0.5	0.8	0.9	0.7
Histidine	<0.05	0.1	<0.05	<0.05	<0.05	0.1	0.1	0.05	0.5	0.3	1.2	0.7
Arginine	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	0.2	0.05	<0.05	0.1	0.1	0.05
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	24	15.6	42.2	27.3	25	27.5	89.1	47.2	63	81.3	699.0	281.1
Total neutral	22	38.8	18.6	26.5	32	40.1	25.2	32.4	39	33.4	16.9	29.8
Myristic acid	0.5	1.3		0.9	t	0.6		0.3	t	1.4		0.7
Palmitic acid	2.8	4.0		3.4	4.2	4.2		4.2	5.2	3.8		4.5
Stearic acid	10.1	18.0		14.0	15.9	18.1		17.0	20.5	17.7		19.1
Unsaturated C_{18} acids	1.0	1.4		1.2	1.5	1.4		1.4	0.6	1.1		0.8
Glycerides												
Mono-	t	-		t	t	0.9		0.4	t	-		t
Di-	-	1.0		0.5	-	1.0		0.5	t	-		t
Tri	-	-		-	-	1.6		0.8	t	-		t
Other[7]	2.0	10.4		6.2	6.2	9.9		8.0	2.6	8.0		5.3
Unsaponifiable		5	2.5	3.8		6	3.2	4.6		5	2.7	3.8
Elemental												
K (potassium)	12	16	12	13	12	12	12	12	69	53	70	64
Na (sodium)	9.2	10	8	9.1	6.3	6.8	6.8	6.6	62	42	57	54
Ca (calcium)	14	20	13	16	28	21	24	24	21	20	21	21
Cu (copper)[8]	14	30	30	25	32	60	50	47	20	20	40	26
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	12.3	15.0	10.3	12.5	8.3	9.2	8.4	8.6	86	67	82	78
S (sulfur)	3.1	3.2	2.2	2.8	4.1	2.4	2.8	3.1	8.0	7.1	8.2	7.8
P (phosphorus)	4.4	7.2	4.0	5.2	9.0	9.6	9.2	9.3	10.2	10.6	7.6	9.5
B (boron)[8]	35	58	23	37	34	48	25	36	64	30	53	49
As (arsenic)[8]	<1	<1	1	<1	<1	<1	2	1	<1	<1	<1	<1
Se (selenium)[8]		<2	<2	<2		<2	<2	<2		6	<2	3

See footnotes at end of table 2.

TABLE 7.--Chemical analyses of waste from cattle Feedlot E

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	358	382	610	450				
Volatile solids	494	616	429	513				
Ash	506	384	571	487				
pH	7.3	7.0	6.6	6.9	7.15	6.95	6.6	6.9
Alkalinity[4]	0.70	0	0.01	0.23				
COD	645	671	530	615	1045	1280	1080	1135
BOD	70	105		88	308	186		247
Nitrogen compounds								
Total Kjeldahl	18.57	21.84	21.21	20.5	49.8	56.5	74.0	60.1
Non-protein								
Urea					1.0	0	0	0.3
Ammonia					7.1	14.2	31.6	17.6
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	0.002	0.003	0.002
Total amino acids	67.7	74.8	66.5	69.6	156.4	156.3	164.9	159.2

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	37.0	39.8	31.6	36.1	56.6	49.3	57.2	54.3	6.4	10.9	11.2	9.5
Carbohydrate												
Total netural	419	346	330	365	241	294	272	269	62	85	89	79
Glucose	367	320	297	33	217	272	242	244	54	72	80	69
Galactose	19	10	11	13	9	10	10	10	4	5	2	4
Mannose	14	8	8	10	5	6	8	6	2	5	2	3
Xylose	14	6	8	9	8	5	8	7	2	3	3	3
Arabinose	5	2	6	4	2	1	4	2	[5]t	t	2	0.7
Cellulose	221	268	308	266	143	118	130	130	1	7	8	5
Hemicellulose	52	26	33	37	24	22	30	25	8	13	9	10
Lignin	118	68	66	84	65	41	48	51				
Phytic acid	1.32	1.38	1.06	1.25	0.41	0.38	0.40	0.40	0.20	0.20	0.23	0.21

See footnotes at end of table 2.

TABLE 7.--Chemical analyses of waste from cattle Feedlot E--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	3	10	13	9	20	11	12	14	35	51	46	44
Glucose	1	3	6	3	9	8	6	8	19	31	36	29
Oligosaccharides	2	7	7	5	11	3	6	7	16	20	10	15
Nitrogen compounds												
Total Kjeldahl	15.9	15.1	14.5	15.2	16.8	19.6	14.6	17.0	49.8	56.5	74.0	60.1
Total amino acids	54.2	58.6	50.5	54.4	66.5	70.0	55.9	64.1	156.4	156.3	164.9	159.2
Alanine	4.6	5.1	9.6	6.4	5.6	5.9	3.6	5.0	16.5	15.7	107.8	46.7
Valine	3.7	3.8	2.7	3.4	4.3	4.5	3.8	4.2	10.8	10.2	4.3	8.4
Glycine	3.7	3.9	2.9	3.5	4.5	4.2	2.7	3.8	9.8	9.2	4.1	7.7
Isoleucine	2.9	2.9	1.9	2.5	3.5	3.8	7.2	4.8	8.4	8.7	2.4	6.5
Leucine	4.7	5.6	4.1	4.8	5.7	6.3	3.3	5.1	12.6	12.6	5.5	10.2
Proline	3.1	3.6	2.8	3.1	3.6	3.7	2.4	3.2	5.9	5.3	2.7	4.6
Threonine	2.6	2.8	2.3	2.5	3.1	3.1	2.7	3.0	7.5	7.9	3.3	6.2
Serine	2.4	2.2	2.2	2.3	3.0	2.8	0.3	2.0	5.8	6.4	2.6	4.9
Methionine	1.0	1.1	0.8	1.0	1.1	1.6	1.1	1.3	5.6	4.6	3.6	4.6
Hydroxyproline	0.8	0.8	0.8	0.8	0.7	0.4	0.4	0.5	0.6	0.3	<0.05	0.3
Phenylalanine	2.8	3.0	2.3	2.7	3.5	3.4	3.0	3.3	8.5	8.2	3.1	6.6
Aspartic acid	5.8	5.6	4.4	5.3	6.8	6.8	5.9	6.5	17.7	17.6	7.7	14.3
Glutamic acid	9.8	11.2	8.4	9.8	12.7	15.8	13.0	13.8	24.5	26.9	10.1	20.5
Tyrosine	1.4	1.7	1.3	1.5	2.0	2.4	2.1	2.2	6.4	7.2	2.3	5.3
Lysine	2.9	2.9	2.2	2.7	3.5	4.0	3.1	3.5	9.1	9.5	2.9	7.1
Histidine	0.4	1.2	0.5	0.7	0.9	0.5	0.8	0.7	2.4	1.4	1.0	1.6
Arginine	1.6	1.4	0.9	1.3	1.7	0.7	0.3	0.9	4.2	4.1	1.3	3.2
Cystine	<0.05	<0.05	0.4	0.1	0.2	0.1	0.2	0.2	<0.05	0.4	<0.05	0.1
Free amino acids	1.5	0.7	6.3	2.8	1.2	0.7	4.0	2.0	19.5	7.4	47.0	24.6
Alanine	0.3	0.5	4.8	1.9	0.1	0.2	3.0	1.1	4.3	2.9	40.5	15.9
Valine	0.2	<0.05	0.1	0.1	0.1	0.1	0.1	0.1	2.0	0.8	0.8	1.2
Glycine	0.1	0.1	0.1	0.1	0.3	<0.05	0.1	0.1	0.7	0.2	0.6	0.5
Isoleucine	0.1	<0.05	0.1	0.05	0.1	<0.05	0.1	0.05	1.1	0.4	0.4	0.6
Leucine	0.1	<0.05	0.1	0.05	0.1	<0.05	0.1	0.05	1.4	0.5	0.5	0.8
Proline	<0.05	0.1	0.1	0.05	0.1	0.1	0.1	0.1	0.5	0.4	0.4	0.4

Threonine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	0.1	0.1	0.2
Serine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.3	0.1	0.1	0.2
Methionine	0.1	<0.05	<0.05	<0.05	0.1	0.1	0.1	0.1	0.7	0.1	0.1	0.3
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05
Phenylalanine	0.1	<0.05	0.1	0.05	<0.05	<0.05	0.1	<0.05	0.8	0.3	0.3	0.5
Aspartic acid	0.1	<0.05	0.1	0.05	0.1	<0.05	<0.05	<0.05	0.9	0.2	0.6	0.6
Glutamic acid	0.4	0.1	0.3	0.3	0.2	0.3	0.1	0.2	3.9	0.5	1.4	1.9
Tyrosine	0.1	<0.05	0.1	0.05	<0.05	<0.05	0.1	<0.05	1.0	0.2	0.3	0.5
Lysine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.0	0.5	0.2	0.6
Histidine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.5	0.2
Arginine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.1	0.05
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	16	14.7	17.2	16.0	14	18.5	66.8	33.1	151	78.1	457.8	228.9
Total neutral	15	12.5	11.2	12.9	13	21.7	13.8	16.2	36	43.1	9.3	29.5
Myristic acid	t	0.2		0.1	t	0.2		0.1	t	1.5		0.8
Palmitic acid	1.7	1.1		1.4	1.7	1.7		1.7	5.5	3.4		4.4
Stearic acid	6.2	7.0		6.6	6.6	10.5		8.6	20.2	24.5		22.4
Unsaturated C_{18} acids	0.6	0.3		0.4	0.4	0.5		0.4	1.8	1.2		1.5
Glycerides												
Mono-	-	t		t	t	t		t	-	-		-
Di-	-	0.2		0.1	t	0.3		0.2	-	0.4		0.2
Tri-	-	t		t	t	0.6		0.3	-	t		t
Other[7]	2.0	2.9		2.4	1.3	7.2		4.2	1.8	9.3		5.5
Unsaponifiable		2	1.9	2.0		3	1.9	2.4		4	2.5	3.2
Elemental												
K (potassium)	10	6.8	9.0	8.6	9.6	8.6	10	9.4	57	43	83	61
Na (sodium)	2.6	1.6	2.4	2.2	1.4	1.0	1.6	1.3	21	14	34	23
Ca (calcium)	18	9.3	14	8.4	23	17	19	19.6	19	20	21	20
Cu (copper)[8]	44	50	60	51	40	110	100	83	52	40	20	37
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	<0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	2.4	2.0	2.9	2.4	0.66	1.0	1.6	1.1	33	26	54	38
S (sulfur)	1.4	1.4	1.9	1.6	1.4	1.8	2.3	1.8	5.4	7.0	11.5	8
P (phosphorus)	5.4	4.4	3.2	4.3	6.2	7.2	6.0	6.5	12.8	12.4	8.8	11.3
B (boron)[8]	43	24	22	29	30	38	26	31	60	42	54	52
As (arsenic)[8]	2	<1	2	1	3	3	4	3	5	4	5	5
Se (selenium)[8]		<2	<2	<2		<2	3	2		15	3	9

See footnotes at end of table 2.

TABLE 8.--Chemical analyses of waste from hog Feedlot F

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	326	319	165	270				
Volatile solids	898	874	855	876				
Ash	102	126	145	124				
pH	5.85	6.55	6.35	6.25	5.9	6.35	6.4	6.2
Alkalinity[4]	0.45	0.17	0.09	0.24				
COD	1180	1030	1130	1113.3	1650	1250	2420	1773
BOD	480	460		470	636	353		494
Nitrogen compounds								
Total Kjeldahl	55.31	39.93	43.09	46.11	79.9	89.6	146.0	105.2
Non-protein					0.1	0.4	0	0.2
Urea					20.4	32.4	158.0	70.3
Ammonia					<0.05	<0.05	<0.05	<0.05
Nitrate					<0.002	<0.002	<0.002	<0.002
Nitrite								
Total amino acids	201.0	154.2	127.0	160.7	224.6	222.3	86.3	177.7

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	36.6	57.5	51.3	48.5	50.7	34.4	43.8	43.0	12.9	8.1	4.9	8.6
Carbohydrate												
Total neutral	435	398	361	398	187	179	325	230	78	94	102	91
Glucose	384	354	327	355	156	148	293	199	72	80	96	83
Galactose	16	17	15	16	11	10	14	12	3	6	3	4
Mannose	14	12	8	11	8	11	7	9	1	4	1	2
Xylose	11	12	7	10	8	8	7	8	[5]t	2	1	1
Arabinose	10	3	4	6	4	2	4	3	2	2	1	2
Cellulose	194	248	242	228	124	122	98	115	3	7	11	7
Hemicellulose	51	44	34	43	31	31	32	31	6	14	6	9
Lignin	23	20	20	21	11	19	21	17				
Phytic acid[6]	1.67	1.40	1.27	1.45	0.54	0.48	0.44	0.48	0.25	0.22	0.22	0.23

Total soluble saccharides	4	10	6	7	21	18	10	16	40	56	32	43
Glucose	2	3	3	3	10	10	3	8	21	35	20	25
Oligosaccharides	2	7	3	4	11	8	7	8	19	21	12	17
Nitrogen compounds												
Total Kjeldahl	51.5	23.4	28.9	34.6	51.7	55.8	48.2	51.9	79.9	89.6	146.0	105.2
Total amino acids	126.3	109.2	100.3	111.9	248.6	213.5	162.7	208.3	224.6	222.3	86.3	177.7
Alanine	10.8	10.3	7.8	9.6	20.2	18.2	12.2	16.9	23.7	28.2	5.9	19.3
Valine	7.7	7.1	7.0	7.3	15.3	13.5	10.1	12.9	15.0	15.8	5.5	12.1
Glycine	7.5	6.3	6.6	6.8	12.8	10.6	9.4	10.9	15.5	14.1	5.1	11.5
Isoleucine	6.3	6.2	6.3	6.3	14.0	12.9	9.2	12.0	12.4	13.8	4.5	10.2
Leucine	13.0	11.2	9.1	11.1	28.4	25.2	18.1	23.9	17.6	18.6	9.0	15.1
Proline	7.0	5.8	4.2	5.6	13.6	11.5	8.8	11.3	8.5	7.8	5.1	7.1
Threonine	6.2	5.2	5.4	5.6	10.5	9.2	7.8	9.2	11.4	11.4	4.9	9.2
Serine	5.0	4.5	4.3	4.6	9.4	8.5	8.7	8.9	8.1	7.6	4.4	6.7
Methionine	3.2	2.9	2.5	2.9	6.1	5.1	0.6	3.9	7.7	5.3	2.6	5.2
Hydroxyproline	1.2	1.2	0.2	0.9	<0.05	0.3	2.4	0.9	<0.05	0.4	1.4	0.6
Phenylalanine	6.9	5.8	4.9	5.9	14.0	12.3	9.5	11.9	10.3	10.5	4.9	8.6
Aspartic acid	12.3	10.4	12.3	11.7	23.2	20.0	15.2	19.5	24.4	25.0	8.5	19.3
Glutamic acid	19.4	16.2	16.0	17.2	41.1	34.7	24.4	33.4	32.7	30.0	11.7	24.8
Tyrosine	5.4	4.4	3.7	4.5	11.6	9.6	7.8	9.6	9.9	10.1	3.2	7.7
Lysine	7.8	6.3	6.3	6.8	13.7	10.9	7.8	7.2	17.2	15.9	4.8	12.6
Histidine	2.7	1.8	1.1	1.9	4.9	2.9	2.4	3.4	3.0	1.9	1.6	6.4
Arginine	3.8	3.4	2.4	3.2	9.6	7.0	7.6	8.1	7.1	5.0	3.1	5.1
Cystine	<0.05	0.3	0.2	0.2	<0.05	1.2	0.7	0.6	<0.05	0.8	<0.05	0.3
Free amino acids	12.8	8.9	3.9	8.5	12.7	6.9	6.8	8.8	53.8	51.3	26.3	43.8
Alanine	2.3	2.6	0.4	1.8	2.2	2.0	0.7	1.6	9.6	12.3	2.4	8.1
Valine	1.1	0.7	0.3	0.7	1.2	0.6	0.5	0.8	4.4	3.6	2.3	3.4
Glycine	0.7	0.6	0.2	0.5	0.8	0.5	0.4	0.6	2.2	2.7	1.7	2.2
Isoleucine	0.9	0.5	0.3	0.6	1.1	0.4	0.5	0.7	4.0	2.9	2.4	3.1
Leucine	1.1	0.6	0.4	0.7	1.2	0.6	0.9	0.9	4.4	4.0	2.5	3.6
Proline	0.6	0.4	0.2	0.4	0.7	0.4	0.4	0.5	2.4	2.0	1.6	2.0
Threonine	0.5	0.3	0.2	0.3	0.6	0.3	0.3	0.4	2.2	2.0	1.1	1.8
Serine	0.5	0.2	0.2	0.3	0.5	0.1	0.4	0.3	2.1	1.4	1.3	1.6
Methionine	0.6	0.3	0.1	0.3	0.6	0.2	0.5	0.4	2.0	1.4	0.4	1.3
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.2	<0.05	0.1
Phenylalanine	0.6	0.3	0.2	0.4	0.7	0.3	0.5	0.5	1.9	1.8	0.9	1.5
Aspartic acid	0.5	0.5	0.2	0.4	0.2	0.2	0.3	0.2	4.1	3.7	2.2	3.3

See footnotes at end of table 2.

TABLE 8.--Chemical analyses of waste from hog Feedlot F--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	1.6	1.2	0.5	1.1	1.0	0.5	0.6	0.7	7.7	7.1	4.9	6.6
Tyrosine	0.8	0.2	0.3	0.4	0.7	0.2	0.5	0.5	2.4	1.8	0.9	1.7
Lysine	0.7	0.4	0.2	0.4	1.0	0.5	0.3	0.6	3.7	3.6	1.4	2.9
Histidine	0.2	0.1	<0.05	0.1	0.1	<0.05	<0.05	<0.05	0.4	0.4	<0.05	0.3
Arginine	0.1	<0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.3	0.4	0.2	0.3
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	123	112.8	84.3	106.7	137	359.5	91.6	196	262	140.1	642.2	348.1
Total neutral	138	85.2	80.3	101.1	161	303.0	128.7	197.6	97	84.6	109.4	97.0
Myristic acid	t	1.4		0.7	t	4.8		2.4	t	1.1		0.6
Palmitic acid	19.2	14.4		16.8	24.1	53.3		38.7	14.3	8.0		11.2
Stearic acid	73.6	44.7		59.2	93.5	145.7		119.6	51.0	36.7		43.9
Unsaturated C_{18} acids	8.4	5.0		6.7	10.6	23.6		17.1	5.6	3.0		4.3
Glycerides												
Mono-	t	1.2		0.6	t	4.2		2.1	t	2.1		1.0
Di-	3.4	2.1		2.8	3.9	14.2		9.0	3.4	5.2		4.3
Tri-	4.7	4.2		4.4	4.0	23.9		14.0	5.0	0.8		2.9
Other[7]	5.7	9.2		7.5	3.1	23.0		13.1	5.3	25.0		15.2
Unsaponifiable		9	8.0	8.5		12	25.9	19.0		15	28.4	21.7
Elemental												
K (potassium)	20	8.6	4.0	11	9.2	8.6	3.6	7.1	58	71	68	66
Na (sodium)	5.3	4.2	6.4	5.3	21	4.0	6.4	10	14	38	60	37
Ca (calcium)	16	5.5	17	13	18	23	40	27	9.0	14	15	13
Cu (copper)[8]	320	50	430	267	440	180	1140	590	270	50	940	420
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	0.9	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	3.1	2.0	2.1	2.4	1.3	2.5	1.3	1.7	12	24	49	28.3
S (sulfur)	2.4	2.4	3.7	2.8	1.7	4.4	5.6	3.9	3.0	16.4	34.9	18.1
P (phosphorus)	19.0	7.8	13.6	13.5	22.0	30.4	30.8	27.7	31.3	31.2	24.8	29.1
B (boron)[8]	25	15	21	20	16	13	16	15	35	26	123	61
As (arsenic)[8]	<1	6	49	18	<1	14	170	61	<1	20	530	183
Se (selenium)[8]		<2	<2	<2		<2	<2	<2		7	5	6

See footnotes at end of table 2.

TABLE 9.--Chemical analyses of waste from cattle Feedlot G

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	457	266	322	348				
Volatile solids	776	895	728	800				
Ash	224	105	272	200				
pH	5.8	6.1	6.2	6.0	6.1	6.3	6.2	6.2
Alkalinity[4]	0.25	0.18	0.13	0.19				
COD	745	1090	791	875	1470	1580	1250	1433
BOD	255	250		252	463	410		436
Nitrogen compounds								
Total Kjeldahl	37.26	25.17	24.84	29.09	74.6	60.3	62.3	65.7
Non-protein								
Urea					0.1	0.3	0.3	0.2
Ammonia					22.5	10.5	15.5	16.2
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	<0.002	<0.002
Total amino acids	119.0	91.8	79.8	96.9	191.8	179.1	168.6	179.8

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of Total	44.0	67.0	68.6	59.8	37.6	18.9	19.0	25.2	18.4	14.1	12.4	15.0
Carbohydrate												
Total neutral	408	369	378	385	143	217	312	224	78	66	71	72
Glucose	356	341	338	345	126	192	284	201	71	58	71	67
Galactose	18	11	12	14	7	11	9	9	3	2	st	2
Mannose	13	8	10	10	5	8	6	6	2	3	t	2
Xylose	17	7	12	12	4	4	8	6	2	3	t	2
Arabinose	4	2	6	4	1	2	5	3	t	t	t	t
Cellulose	195	281	276	251	125	150	128	134	3	4	7	5
Hemicellulose	52	28	40	40	17	25	28	23	7	8	t	5
Lignin	52	61	67	60	49	36	50	45				
Phytic acid[6]	1.13	1.24	1.12	1.16	0.37	0.31	0.46	0.38	0.17	0.19	0.19	0.18

See footnotes at end of table 2.

TABLE 9.--Chemical analyses of waste from cattle Feedlot G--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	4	5	6	5	17	13	12	14	42	40	31	38
Glucose	2	2	3	2	6	10	8	8	22	26	24	24
Oligosaccharides	2	3	3	3	11	3	4	6	20	14	7	14
Nitrogen compounds												
Total Kjeldahl	27.7	16.8	19.3	21.3	30.1	28.7	20.3	26.4	74.6	60.3	62.3	65.7
Total amino acids	90.8	68.9	55.1	71.6	116.1	107.2	111.2	111.5	191.8	179.1	168.6	179.8
Alanine	14.8	6.4	8.5	9.9	13.9	9.3	13.5	12.2	59.9	18.9	44.8	41.2
Valine	5.2	4.2	3.4	4.3	6.7	6.6	7.2	6.8	9.2	11.2	9.4	9.9
Glycine	6.0	4.2	3.9	4.7	7.2	6.3	7.7	7.1	15.2	12.7	13.8	13.9
Isoleucine	4.0	3.2	2.9	3.3	5.5	5.5	6.7	5.9	6.8	9.3	7.9	8.0
Leucine	8.3	6.7	5.2	6.7	11.7	9.8	10.7	10.7	11.2	13.2	12.0	12.1
Proline	5.3	4.3	3.3	4.3	6.9	6.3	6.3	6.5	6.3	7.1	6.3	6.6
Threonine	4.1	3.4	2.3	3.3	4.9	4.9	4.3	4.7	7.3	10.1	6.3	7.9
Serine	3.8	2.7	1.8	2.8	4.5	4.0	2.9	3.8	5.2	6.9	3.6	5.2
Methionine	1.5	1.4	1.2	1.4	2.2	2.4	2.6	2.4	4.1	4.2	4.1	4.1
Hydroxyproline	0.5	0.5	0.2	0.4	<0.05	0.4	0.2	0.2	<0.05	0.3	<0.05	0.1
Phenylalanine	4.2	3.6	2.6	3.5	6.0	5.4	5.7	5.7	7.2	8.8	6.8	7.6
Aspartic acid	7.8	6.5	4.8	6.3	10.9	10.1	10.5	10.5	16.3	19.3	14.2	16.6
Glutamic acid	14.0	12.5	8.6	11.7	19.9	20.0	18.1	19.3	22.8	27.0	21.6	23.8
Tyrosine	2.9	2.4	1.5	2.3	4.3	4.0	3.2	3.8	5.6	7.9	4.3	5.9
Lysine	4.3	3.6	2.5	3.5	6.1	6.3	6.0	6.1	9.2	11.0	7.5	9.2
Histidine	0.7	1.4	0.9	1.0	1.5	2.2	2.0	1.9	2.5	4.8	2.0	3.1
Arginine	2.8	1.7	1.3	1.9	3.6	3.2	2.3	3.0	3.0	4.9	3.4	3.7
Cystine	0.5	0.3	0.3	0.4	0.2	0.6	1.2	0.6	<0.05	1.4	0.6	0.7
Free amino acids	9.7	3.3	8.6	7.2	5.7	4.9	6.6	6.7	50.0	17.2	42.5	36.5
Alanine	6.9	1.1	5.0	4.3	3.8	1.2	3.7	2.9	34.1	5.0	23.9	21.0
Valine	0.2	0.2	0.4	0.3	0.2	0.3	0.3	0.3	1.3	1.2	1.9	1.5
Glycine	0.7	0.4	0.9	0.6	0.3	0.5	0.7	0.5	3.5	1.7	4.5	3.2
Isoleucine	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.9	0.6	1.0	0.8
Leucine	0.2	0.1	0.3	0.2	0.1	0.2	0.3	0.2	1.2	0.7	1.5	1.1
Proline	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	1.1	1.1	1.5	1.2

Threonine	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.4	0.6	0.8	0.6
Serine	0.1	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.05	0.4	0.3	0.2	0.3
Methionine	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.5	0.4	0.4	0.4
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.1	0.05
Phenylalanine	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.7	0.5	0.8	0.7
Aspartic acid	0.1	0.2	0.2	0.2	0.1	0.3	0.2	0.2	0.9	0.8	0.9	0.9
Glutamic acid	0.4	0.5	0.5	0.5	0.2	0.7	0.3	0.4	2.5	2.4	2.4	2.4
Tyrosine	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.8	0.6	0.9	0.8
Lysine	0.1	0.3	0.1	0.2	0.1	0.4	0.1	0.2	1.0	1.2	0.8	1.0
Histidine	0.1	<0.05	<0.05	<0.05	0.1	<0.05	0.1	0.05	0.4	0.1	0.7	0.4
Arginine	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	0.2	<0.05	0.2	0.1
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	31	28.1	36.9	32.0	10	30.1	58.2	32.8	26.8	116.6	566.6	317.1
Total neutral	21	42.5	15.3	26.3	23	29.1	33.8	28.6	38	49.5	27.8	38.4
Myristic acid	t	-		t	t	0.2		0.1	t	0.8		0.4
Palmitic acid	1.6	-		0.8	2.0	2.3		2.2	2.8	2.4		2.6
Stearic acid	13.1	18.6		15.8	13.4	15.4		14.4	31.0	26.2		28.6
Unsaturated C_{18} acids	t	0.8		0.4	1.0	0.7		0.8	-	0.7		0.4
Glycerides												
Mono-	-	0.5		0.2	t	0.6		0.3	-	1.2		0.6
Di-	-	1.1		0.6	-	0.6		0.3	-	-		-
Tri-	-	3.1		1.6	t	2.0		1.0	-	1.6		0.8
Other[7]	1.6	14.0		7.8	3.5	6.1		4.8	-	14.0		7.0
Unsaponifiable		9	1.7	5.4		2	2.9	2.4		5	2.1	3.5
Elemental												
K (potassium)	10	4.8	8.4	7.7	6.4	5.4	9.0	6.9	42	27	51	40
Na (sodium)	2.8	1.8	1.6	2.1	1.4	1.6	1.4	1.5	13	9.6	11	11
Ca (calcium)	9.0	4.5	17	10	11	3.8	19	11	15	13	23	17
Cu (copper)[8]	14	10	40	21	22	20	50	31	18	10	40	23
Pb (lead)[8]	<0.1	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	<0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	4.3	1.6	2.8	2.9	2.0	1.6	1.7	1.8	23.5	13	20	18.8
S (sulfur)	2.0	2.0	1.9	2.0	1.8	1.6	2.8	2.1	4.6	3.9	4.7	4.4
P (phosphorus)	6.8	3.4	4.4	4.9	7.2	6.4	6.8	6.8	15.2	17.6	14.8	15.9
B (boron)[8]	11	12	16	13	19	8	16	14	31	9	21	20
As (arsenic)[8]	<1	<1	1	<1	<1	<1	3	1	<1	<1	4	1
Se (selenium)[8]		<2	4	2		4	<2	2		4	<2	2

See footnotes at end of table 2.

TABLE 10.--Chemical analyses of waste from cattle Feedlot H

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	372	220	441	344				
Volatile solids	625	896	493	671				
Ash	375	104	507	329				
pH	5.8	5.8	5.45	5.7	6.2	5.85	5.45	5.8
Alkalinity[4]	0.19	0.34	0.24	0.26				
COD	552	990	548	697	1153	1450	1150	1251
BOD	166	235		200	283	275		279
Nitrogen compounds								
Total Kjeldahl	21.06	29.02	24.00	24.69	51.0	62.9	42.1	52.0
Non-protein								
Urea					0.1	0.1	0.2	0.1
Ammonia					15.5	13.9	33.8	21.0
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	<0.002	<0.002
Total amino acids	76.3	98.3	63.7	79.4	119.7	167.9	89.9	125.8

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	46.0	63.1	38.1	49.0	46.9	23.9	48.8	39.8	7.1	13.0	13.1	11.0
Carbohydrate												
Total neutral	180	317	332	276	124	208	234	187	28	81	61	57
Glucose	159	288	288	245	114	182	202	166	24	74	58	52
Galactose	4	12	12	9	6	10	10	9	2	3	1	2
Mannose	8	7	12	9	4	8	6	6	2	4	3	3
Xylose	4	7	12	8	[5]t	6	10	5	t	t	4	1
Arabinose	t	3	8	4	t	2	6	3	t	t	1	t
Cellulose	88	208	197	164	87	98	108	68	1	3	8	4
Hemicellulose	16	29	44	30	10	26	32	23	4	7	9	7
Lignin	70	46	59	58	51	34	44	43				
Phytic acid[6]	1.43	1.27	1.10	1.26	0.36	0.31	0.43	0.36	0.13	0.13	0.19	0.15

Total soluble saccharides	2	12	10	8	7	8	10	8	26	36	43	35
Glucose	1	4	4	3	3	4	4	4	18	20	32	23
Oligosaccharides	1	8	6	5	5	4	6	5	8	16	15	13
Nitrogen compounds												
Total Kjeldahl	18.8	21.8	15.2	18.6	18.7	29.7	26.0	24.8	51.0	62.9	42.1	52.0
Total amino acids	60.8	74.8	38.6	58.1	84.9	122.8	76.2	94.6	119.7	167.9	89.9	125.8
Alanine	5.8	7.2	4.0	5.6	8.2	11.2	7.3	8.9	15.0	20.5	20.3	18.6
Valine	3.8	4.4	2.4	3.5	5.5	7.7	5.0	6.1	8.1	10.6	4.9	7.9
Glycine	3.5	5.0	3.0	3.8	5.1	8.0	5.2	6.1	6.7	16.5	13.7	12.3
Isoleucine	3.1	3.7	1.8	2.9	4.5	6.9	4.4	5.3	6.9	8.9	4.1	6.6
Leucine	6.4	7.9	3.6	5.9	8.7	11.7	7.8	9.4	9.3	12.1	5.6	9.0
Proline	4.0	4.9	2.4	3.7	5.4	7.0	4.5	5.6	4.9	6.5	2.8	4.7
Threonine	2.7	3.3	1.6	2.5	3.9	5.6	3.2	4.2	6.2	8.8	3.9	6.3
Serine	2.3	3.1	1.4	2.3	3.2	4.8	2.8	3.6	4.0	6.1	2.7	4.3
Methionine	1.2	1.6	0.7	1.2	1.8	3.0	1.9	2.2	3.8	4.4	1.5	3.2
Hydroxyproline	0.2	0.3	0.3	0.3	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	0.3	0.1
Phenylalanine	3.0	4.0	1.7	2.9	4.2	6.3	4.0	4.8	5.6	8.2	3.1	5.6
Aspartic acid	5.9	6.5	3.2	5.2	8.5	11.4	7.1	9.0	13.2	17.1	7.2	12.5
Glutamic acid	10.9	12.4	6.0	9.8	15.2	19.6	13.2	16.0	19.6	23.9	10.5	18.0
Tyrosine	1.9	2.6	1.0	1.8	2.7	4.9	2.3	3.3	4.5	6.8	2.2	4.5
Lysine	2.9	3.2	2.9	3.0	4.1	6.6	4.0	4.9	6.6	9.2	3.7	6.5
Histidine	0.6	2.3	0.8	1.2	1.3	3.2	1.9	2.1	1.7	3.2	1.4	2.1
Arginine	2.5	1.4	1.5	1.8	2.5	3.6	1.4	2.5	3.1	3.7	1.4	2.7
Cystine	<0.05	0.6	0.2	0.3	0.2	1.0	0.2	0.5	0.5	1.4	0.7	0.9
Free amino acids	0.9	4.2	4.1	3.1	1.4	4.8	2.5	2.9	14.0	24.5	27.9	22.1
Alanine	0.4	1.3	1.5	1.1	0.4	1.3	1.1	0.9	5.4	7.1	11.2	7.9
Valine	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.1	1.2	1.3	1.6	1.4
Glycine	0.1	0.9	1.1	0.7	0.1	1.0	0.7	0.6	0.3	5.3	7.3	4.3
Isoleucine	<0.05	0.1	0.2	0.1	<0.05	0.1	0.1	0.05	0.6	0.8	0.1	0.5
Leucine	<0.05	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.6	1.0	1.3	1.0
Proline	<0.05	0.1	0.1	0.05	<0.05	0.1	<0.05	<0.05	0.2	0.7	0.5	0.5
Threonine	<0.05	0.1	0.1	0.05	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.5
Serine	<0.05	0.1	0.1	0.05	0.1	0.1	<0.05	0.05	0.2	0.5	0.4	0.4
Methionine	<0.05	0.2	<0.05	0.05	0.1	0.1	<0.05	0.05	0.3	0.7	0.4	0.5
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05
Phenylalanine	<0.05	0.1	0.1	0.05	0.1	0.1	0.1	0.1	0.5	0.7	0.5	0.6
Aspartic acid	<0.05	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.6	0.7	0.5

See footnotes at end of table 2.

TABLE 10.--Chemical analyses of waste from cattle Feedlot H--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	0.2	0.4	0.2	0.3	0.3	0.5	0.1	0.3	2.9	2.2	1.4	2.2
Tyrosine	0.1	0.2	0.1	0.1	<0.05	0.2	0.1	0.1	0.5	0.9	0.7	0.7
Lysine	0.1	0.2	0.1	0.1	<0.05	0.3	<0.05	0.1	0.6	1.1	0.6	0.8
Histidine	<0.05	0.1	0.1	0.05	<0.05	0.1	<0.05	<0.05	<0.05	0.5	0.5	0.3
Arginine	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	0.1	0.5	<0.05	0.2
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	10	24.2	26.3	16.8	7	25.7	28.6	21.4	67	97.3	595	253.1
Total neutral	10	24.5	12.4	12.3	10	33.6	14.8	19.5	34	45.7	15.9	31.9
Myristic acid	-	0.4		0.2	-	0.3		0.2	-	0.8		0.4
Palmitic acid	1.1	1.7		1.4	-	2.6		1.3	-	3.0		1.5
Stearic acid	6.4	12.2		9.3	-	13.5		6.8	-	25.2		12.6
Unsaturated C_{18} acids	t	0.4		0.2	-	0.6		0.3	-	0.7		0.4
Glycerides												
Mono-	-	0.7		0.4	-	1.2		0.6	-	1.2		0.6
Di-	-	0.5		0.2	-	0.7		0.4	-	0.4		0.2
Tri-	-	0.5		0.2	-	1.3		0.6	-	0.9		0.4
Other[7]	t	6.7		3.4	-	11.6		5.8	-	10.6		5.3
Unsaponifiable		3	1.3	2.2		3	1.5	2.2		3	3.2	3.1
Elemental												
K (potassium)	7.2	6	6	6.4	6.4	6	5.4	5.9	54	33	43	43
Na (sodium)	3.4	4	3.6	3.7	2.2	3.6	2	2.6	38	23	37	33
Ca (calcium)	16	4.5	15	12	21	8.3	24	18	17	14	22	18
Cu (copper)[8]	24	20	30	25	34	30	50	38	26	30	30	29
Pb (lead)[8]	0.12	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	4.8	4.8	2.9	4.2	2.1	4.3	2.0	2.8	69	33	57	53
S (sulfur)	1.4	2.0	1.4	1.6	1.6	1.8	1.9	1.8	4.8	4.4	6.5	5.2
P (phosphorus)	3.2	4.6	2.4	3.4	3.6	5.8	2.8	4.1	12.8	19.4	14.4	15.5
B (boron)[8]	8	14	13	12	26	6	18	17	23	16	20	20
As (arsenic)[8]	1	<1	2	1	2	<1	3	2	6	<1	5	4
Se (selenium)[8]		<2	<2	<2		4	<2	2		10	<2	5

See footnotes at end of table 2.

TABLE 11.--Chemical analyses of waste from hog Feedlot I

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	440	297	344	360				
Volatile solids	720	829	767	772				
Ash	280	171	233	228				
pH	5.9	6.0	6.3	6.1	5.85	6.05	6.3	6.1
Alkalinity[4]	0.21	0.24	0.11	0.19				
COD	813	1220	860	964	1410	1380	1420	1070
BOD	310	340		325	603	492		548
Nitrogen compounds								
Total Kjeldahl	31.76	33.92	27.37	31.02	60.3	69.2	61.6	63.7
Non-protein								
Urea					0.2	0.0	0.0	0.1
Ammonia					13.5	12.3	13.9	13.2
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					0.002	0.002	0.002	0.002
Total amino acids	146.1	156.6	114.7	139.1	176.7	217.6	179.9	191.4

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	20.5	52.0	54.4	42.3	70.3	40.1	38.8	49.7	9.2	7.9	6.8	7.9
Carbohydrate												
Total neutral	397	410	395	401	196	178	250	208	85	88	95	89
Glucose	345	360	348	351	179	148	214	180	78	78	88	81
Galactose	17	18	15	17	6	12	13	10	4	4	2	3
Mannose	15	15	12	14	6	10	10	9	3	2	2	2
Xylose	15	13	10	13	4	6	8	6	[5]t	2	1	1
Arabinose	5	4	10	6	1	2	5	3	t	2	2	1
Cellulose	197	230	315	248	130	127	147	135	5	4	10	6
Hemicellulose	52	50	47	50	17	30	36	28	7	10	7	8
Lignin	19	21	20	20	12	12	16	13				
Phytic acid[6]	1.80	1.68	1.24	1.57	0.36	0.30	0.47	0.38	0.14	0.14	0.24	0.17

See footnotes at end of table 2.

TABLE 11.--Chemical analyses of waste from hog feedlot I--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	3	15	7	8	22	13	14	16	39	46	44	43
Glucose	1	6	3	3	10	6	6	7	20	22	30	24
Oligosaccharides	2	9	4	5	12	7	8	9	18	24	14	19
Nitrogen compounds												
Total Kjeldahl	28.2	19.4	18.8	22.1	29.1	45.8	33.4	36.1	60.3	69.2	61.6	63.7
Total amino acids	98.3	84.7	63.9	82.3	156.0	237.9	174.6	189.5	176.7	217.6	179.9	191.4
Alanine	8.5	8.2	5.4	7.4	13.2	21.0	14.6	16.3	21.8	25.1	20.7	22.5
Valine	6.7	5.4	3.8	5.3	10.4	14.8	11.2	12.1	12.1	15.3	12.7	13.4
Glycine	5.0	5.2	3.9	4.7	7.7	11.9	9.8	9.8	11.5	13.7	12.1	12.4
Isoleucine	5.5	4.7	3.0	4.9	9.1	13.4	9.7	10.7	10.0	13.5	10.6	11.4
Leucine	10.5	8.8	6.2	8.5	18.4	27.9	18.4	21.6	13.4	17.0	14.2	14.9
Proline	5.9	5.5	3.9	5.1	9.3	13.8	8.8	10.6	7.5	9.0	7.7	8.1
Threonine	4.9	4.2	3.4	4.2	6.7	9.9	7.7	8.1	9.9	12.3	9.3	10.5
Serine	4.0	3.5	3.0	3.5	6.2	9.9	7.0	7.9	7.1	8.4	6.8	7.4
Methionine	2.5	2.0	1.5	2.0	3.7	4.6	4.1	4.1	8.4	6.9	5.5	8.8
Hydroxyproline	0.9	1.5	1.1	1.2	0.2	0.5	0.4	0.4	0.2	0.5	0.4	0.4
Phenylalanine	5.4	4.5	3.3	4.4	9.2	13.2	9.5	10.6	8.0	10.0	8.4	12.1
Aspartic acid	9.5	7.8	6.1	7.8	15.6	22.0	18.1	18.6	18.6	24.7	20.6	21.3
Glutamic acid	14.6	12.2	9.5	12.1	25.9	38.9	27.5	30.8	23.8	29.0	26.1	26.3
Tyrosine	3.6	3.1	2.2	3.0	6.5	11.0	7.2	8.2	6.6	10.3	7.1	8.0
Lysine	5.3	4.1	3.4	4.3	7.8	10.5	10.2	9.5	12.1	13.6	10.1	11.9
Histidine	1.8	2.1	1.5	1.8	2.2	5.6	3.4	3.7	1.5	2.5	2.6	2.2
Arginine	3.6	2.0	2.3	2.6	3.5	7.5	5.9	5.6	4.1	5.2	3.5	4.3
Cystine	<0.05	<0.05	0.3	0.1	0.5	1.4	1.1	1.0	<0.05	0.8	1.3	0.7
Free amino acids	6.0	7.0	4.8	5.9	4.5	7.6	5.2	1.5	37.8	44.8	26.0	36.2
Alanine	1.5	2.1	1.1	1.6	1.1	2.3	1.1	1.5	9.9	11.7	5.6	9.1
Valine	0.5	0.5	0.4	0.5	0.5	0.6	0.5	0.5	2.8	3.7	2.5	3.0
Glycine	0.4	0.6	0.4	0.5	0.3	0.8	0.4	0.5	2.1	1.8	1.4	1.8
Isoleucine	0.4	0.3	0.3	0.3	0.4	0.3	0.4	0.4	2.3	2.8	1.8	2.3
Leucine	0.6	0.5	0.4	0.5	0.5	0.5	0.5	0.5	3.0	3.5	2.1	2.9
Proline	0.4	0.6	0.4	0.5	0.3	0.8	0.4	0.5	2.0	3.0	2.2	2.4

Threonine	0.3	<0.05	0.2	0.2	0.2	<0.05	0.1	0.1	1.6	1.8	0.8	1.4
Serine	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	1.6	1.4	0.8	1.3
Methionine	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	1.5	1.0	0.5	1.0
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.1	0.05
Phenylalanine	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	1.3	1.3	0.7	1.1
Aspartic acid	0.1	0.2	0.2	0.2	<0.05	0.1	0.1	0.05	1.1	1.6	0.9	1.2
Glutamic acid	0.3	0.9	0.6	0.6	0.1	0.6	0.3	0.3	4.8	6.3	4.0	5.0
Tyrosine	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.3	1.5	1.5	0.9	1.3
Lysine	0.4	0.4	0.2	0.3	0.3	0.6	0.4	0.4	2.1	2.1	1.3	1.8
Histidine	<0.05	0.2	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.8	0.3	0.4
Arginine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.05	0.2	0.4	0.3	0.3
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	119	153.9	49.5	107.5	115	165.1	322.1	200.7	195	100.6	729.6	341.7
Total neutral	148	62.8	73.0	94.6	141	141.3	120.4	134.2	71	54.8	49.3	58.3
Myristic acid	1.6	0.6		1.1	t	1.1		0.6	t	0.9		0.4
Palmitic acid	17.9	9.5		13.7	17.7	24.2		21.0	8.5	7.2		7.9
Stearic acid	75.3	34.2		54.8	74.4	74.2		74.3	38.0	28.5		33.3
Unsaturated C_{18} acids	10.6	3.1		6.8	9.2	8.8		9.0	4.5	2.3		3.4
Glycerides												
Mono-	t	1.0		0.5	t	2.1		1.0	t	0.9		0.4
Di-	2.8	1.1		1.3	2.6	3.8		3.2	0.7	1.7		1.2
Tri-	3.0	1.3		2.2	2.5	4.9		3.7	0.8	1.6		1.2
Other[7]	3.1	9.0		6.0	1.4	14.7		8.0	2.8	8.1		5.4
Unsaponifiable		7	5.7	6.4		16	10.4	13.2		19	8.4	13.7
Elemental												
K (potassium)	10	8.8	7.2	8.6	5.2	8.0	7.2	6.8	55	71	61	62.3
Na (sodium)	1.8	1.8	2.0	1.9	0.8	1.4	1.8	1.3	8.2	14	18	13.4
Ca (calcium)	22	15	18	18	31	49	47	42.3	32	31	24	29.0
Cu (copper)[8]	64	30	60	51	80	110	130	110	32	40	60	44
Pb (lead)[8]	0.23	<5	<5	<5	0.18	<5	<5	<5	0.18	<5	<5	<5
Hg (mercury)[8]	<0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	1.1	1.0	0.7	0.93	0.46	0.9	0.8	0.72	7.8	11	2.4	7.1
S (sulfur)	2.2	1.1	1.5	1.6	2.4	1.7	2.6	2.2	3.2	3.2	3.5	3.3
P (phosphorus)	14	11	13.2	12.7	20	35.9	32	29.3	19.2	26.8	19.6	16.5
B (boron)[8]	22	9	4	11.6	17.5	18	15	16.8	15	7	12	11.3
As (arsenic)[8]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Se (selenium)[8]		<2	<2	<2		6	4	5		11	2	6

See footnotes at end of table 2.

TABLE 12.--Average chemical analyses of waste from cattle feedlots including AP samples--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Glutamic acid	0.4	0.4	0.5	0.4	0.3	0.6	0.4	0.4	2.9	2.2	2.9	2.7
Tyrosine	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.6	0.6	0.7	0.6
Lysine	0.1	0.1	0.1	0.1	<0.05	0.2	0.1	0.1	0.6	0.8	0.7	0.7
Histidine	<0.05	0.2	<0.05	0.05	<0.05	0.2	<0.05	0.05	0.3	0.3	0.6	0.4
Arginine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	0.8	0.1	0.1	0.3
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	31.2	24.8	55.4	37.1	35.6	42.9	109.3	62.6	184	85.4	439.2	236.2
Total neutral	24.6	29.8	16.8	23.7	29.7	33.7	23.4	28.9	39.6	40.8	23.3	34.6
Myristic acid	0.4	0.5		0.4	0.7	0.4		0.6	0.2	0.9		0.6
Palmitic acid	3.0	2.7		2.8	4.3	3.7		4.0	5.2	4.0		4.6
Stearic acid	11.3	14.2		12.8	16.1	15.6		15.8	21.2	21.0		21.1
Unsaturated C_{18} acids	1.0	0.8		0.9	1.4	1.0		1.2	1.2	1.0		1.1
Glycerides												
Mono-	-	0.2		0.1	[5]t	0.3		0.2	-	0.3		0.2
Di-	0.1	0.6		0.4	-	0.7		0.4	-	0.3		0.2
Tri-	-	0.4		0.2	-	0.8		0.4	-	0.3		0.2
Other[7]	3.1	8.2		5.6	4.1	9.4		6.8	2.9	10.0		6.4
Unsaponifiable		4.2	1.8	3.0		4.8	2.5	3.6		4.6	2.8	3.7
Elemental												
K (potassium)	12	10	11	11	10	11	10	10	67	59	72	66
Na (sodium)	12	4.7	4.0	6.9	4.0	4.0	3.6	3.9	46	34	40	40
Ca (calcium)	16	12	14	14	18	21	25	21	17	18	20	18
Cu (copper)[8]	30	30	40	30	40	60	80	60	30	30	40	30
Pb (lead)[8]	<0.10	<5	<5	<5	<0.10	<5	<5	<5	<0.10	<5	<5	<5
Hg (mercury)[8]	0.8	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	7.4	7.3	5.5	6.7	4.9	5.6	4.5	5.0	78.5	68.8	76.7	74.7
S (sulfur)	3.2	2.7	2.1	2.7	5.4	2.7	3.2	3.8	11.4	8.4	8.6	9.5
P (phosphorus)	5.2	5.3	3.9	4.8	8.2	8.8	8.8	8.6	10.9	12.0	9.8	10.9
B (boron)[8]	28	30	16	25	29	32	22	28	44	36	34	38
As (arsenic)[8]	<1	<1	<1	<1	1	<1	2	1	2	<1	2	1
Se (selenium)[8]		<2	<2	<2		<2	<2	<2		5	<2	2

See footnotes at end of table 2.

TABLE 13.--Average chemical analyses of waste from hog feedlots

Analysis[1]	Whole waste				Soluble fraction			
Group/specific	1[2]	2	3	Av.	1	2	3	Av.
Standard waste								
Total solids[3]	383	308	254	315				
Volatile solids	809	698	811	773				
Ash	191	148	189	176				
pH	5.9	6.3	6.3	6.15	5.9	6.2	6.45	6.2
Alkalinity[4]	0.33	0.23	0.10	0.22				
COD	996	1155	995	1049	1530	1315	1920	1588
BOD	395	295		345	620	451		536
Nitrogen compounds								
Total Kjeldahl	43.54	36.92	35.23	38.56	70.1	79.4	103.8	84.4
Non-protein								
Urea					0.2	0.2	0.0	0.1
Ammonia					17.0	22.4	86.0	41.8
Nitrate					<0.05	<0.05	<0.05	<0.05
Nitrite					<0.002	<0.002	0.005	<0.002
Total amino acids	173.6	155.2	120.8	149.9	200.6	220.0	133.1	184.6

	Fiber fraction				Particulate fraction				Soluble fraction			
	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Partition												
Percent of total	28.6	54.8	52.8	45.4	60.5	37.2	41.3	46.3	11.0	8.0	5.8	8.3
Carbohydrate												
Total neutral	416	404	378	399	192	178	338	236	82	92	98	91
Glucose	364	357	338	353	168	148	254	190	75	79	92	82
Galactose	16	18	15	16	8	11	14	11	4	5	2	4
Mannose	14	14	10	13	7	10	8	8	2	3	2	2
Xylose	13	12	8	11	6	7	8	7	[5]t	2	1	1
Arabinose	8	4	7	6	2	2	4	3	1	2	2	2
Cellulose	196	239	278	238	127	124	122	124	4	6	10	7
Hemicellulose	52	47	40	46	24	30	34	29	6	12	6	7
Lignin	21	20	20	20	12	16	18	15				
Phytic acid[6]	1.74	1.54	1.26	1.51	0.45	0.39	0.46	0.43	0.20	0.18	0.23	0.20

See footnotes at end of table 2.

TABLE 13.--Average chemical analyses of waste from hog feedlots--continued

Analysis	Fiber fraction				Particulate fraction				Soluble fraction			
Group/specific	1	2	3	Av.	1	2	3	Av.	1	2	3	Av.
Total soluble saccharides	4	12	6	7	22	16	12	17	40	41	38	40
Glucose	2	4	3	3	10	8	4	8	20	28	25	24
Oligosaccharides	2	8	4	5	12	8	8	9	18	22	13	18
Nitrogen compounds												
Total Kjeldahl	39.8	21.4	23.8	28.3	40.4	50.8	40.8	43.9	70.1	79.4	103.8	84.4
Total amino acids	112.3	97.0	82.1	97.1	202.3	225.7	168.6	198.9	200.6	220.0	133.1	184.6
Alanine	9.6	9.2	6.6	8.4	16.7	19.6	13.4	16.6	22.8	26.6	13.3	20.9
Valine	7.2	6.2	5.4	6.3	12.8	14.2	10.6	12.5	13.6	15.6	9.1	12.8
Glycine	6.2	5.8	5.2	5.7	10.2	11.2	9.6	10.3	13.5	13.9	8.6	12.0
Isoleucine	5.9	5.4	4.6	5.3	11.6	13.2	9.4	11.4	11.2	13.6	7.6	10.8
Leucine	11.8	10.0	7.6	9.8	23.4	26.6	18.2	22.7	15.5	17.8	11.6	15.0
Proline	6.4	5.6	4.0	5.3	11.4	12.6	8.8	10.9	8.0	8.4	6.4	7.6
Threonine	5.6	5.7	4.4	5.2	8.6	9.6	7.8	8.7	10.6	11.8	7.1	9.8
Serine	4.5	4.0	3.6	4.0	7.8	9.2	7.8	8.4	7.6	8.0	5.6	7.1
Methionine	2.8	2.4	2.0	2.4	4.9	4.8	2.4	4.0	8.0	7.2	4.0	6.4
Hydroxyproline	1.0	1.4	0.6	1.0	0.1	0.4	1.4	0.6	0.1	0.4	0.9	0.5
Phenylalanine	6.2	5.2	4.1	5.2	11.6	12.8	9.5	11.3	9.2	10.2	6.6	8.7
Aspartic acid	10.9	9.1	9.2	9.7	19.4	21.0	16.6	19.0	21.5	24.8	14.6	20.3
Glutamic acid	17.0	14.2	12.8	14.7	33.4	36.8	26.0	32.0	28.2	29.5	18.9	25.5
Tyrosine	4.5	3.8	3.0	3.8	9.0	10.3	7.5	8.9	8.2	10.2	5.2	7.9
Lysine	6.6	5.2	4.8	5.5	10.8	10.7	9.0	10.2	14.6	14.8	7.4	12.3
Histidine	2.2	2.0	1.3	1.8	3.6	4.2	2.9	3.6	2.2	2.2	2.1	2.2
Arginine	3.7	2.7	2.4	2.9	6.6	7.2	6.8	6.9	5.6	5.1	3.3	4.7
Cystine	<0.05	0.2	0.2	0.1	0.2	1.3	0.9	0.8	<0.05	0.8	0.6	0.5
Free amino acids	9.4	8.0	4.4	7.3	8.6	7.2	6.0	7.3	45.8	48.0	26.2	40.0
Alanine	1.9	2.4	0.8	1.7	1.6	2.2	0.9	1.6	9.8	12.0	4.0	8.6
Valine	0.8	0.6	0.4	0.6	0.8	0.6	0.5	0.6	3.6	3.6	2.4	3.2
Glycine	0.6	0.6	0.3	0.5	0.6	0.6	0.4	0.5	2.2	2.2	1.6	2.0
Isoleucine	0.6	0.4	0.3	0.4	0.8	0.4	0.4	0.5	3.2	2.8	2.1	2.7
Leucine	0.8	0.6	0.4	0.6	0.8	0.6	0.7	0.7	3.7	3.8	2.3	3.3
Proline	0.5	0.5	0.3	0.4	0.5	0.6	0.4	0.5	2.2	2.5	1.9	2.2

Threonine	0.4	0.2	0.2	0.3	0.4	0.2	0.2	0.3	1.9	1.9	1.0	1.6
Serine	0.4	0.2	0.2	0.3	0.4	0.2	0.3	0.3	1.8	1.4	1.0	1.4
Methionine	0.4	0.2	0.1	0.2	0.4	0.2	0.4	0.3	1.8	1.2	0.4	1.5
Hydroxyproline	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.1	0.05	0.1
Phenylalanine	0.4	0.2	0.2	0.3	0.4	0.3	0.4	0.4	1.6	1.6	0.8	1.3
Aspartic acid	0.3	0.4	0.2	0.3	0.1	0.2	0.2	0.2	2.6	2.6	1.6	2.3
Glutamic acid	1.0	1.0	0.6	0.9	0.6	0.6	0.4	0.5	6.2	6.7	4.4	5.8
Tyrosine	0.6	0.2	0.3	0.4	0.4	0.2	0.4	0.3	2.0	1.6	0.9	1.5
Lysine	0.6	0.4	0.2	0.4	0.6	0.6	0.4	0.5	2.9	2.8	1.4	2.4
Histidine	0.1	0.2	<0.05	0.1	0.05	<0.05	<0.05	<0.05	0.2	0.6	0.2	0.3
Arginine	0.05	<0.05	0.05	<0.05	0.05	0.05	0.1	0.05	0.2	0.4	0.2	0.3
Cystine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lipid												
Total	121	133.4	66.9	107.1	126	262.3	206.8	198.4	205	120.4	685.9	337.1
Total neutral	143	74.0	76.6	97.9	151	222.2	124.6	165.9	84	69.7	79.4	77.7
Myristic acid	0.8	1.0		0.9	t	3.0		1.5	t	1.0		0.5
Palmitic acid	18.6	12.0		15.3	20.9	38.8		29.8	11.4	7.6		9.5
Stearic acid	74.4	39.4		53.5	84.0	110.0		97.0	44.5	32.6		38.6
Unsaturated C_{18} acids	9.5	4.0		6.8	9.9	16.2		13.0	5.0	2.6		3.8
Glycerides												
Mono-	t	1.1		0.6	t	3.2		1.6	t	1.5		0.8
Di-	3.1	1.6		1.4	3.2	9.0		6.1	2.0	3.4		2.7
Tri-	3.8	2.8		3.3	3.2	14.4		8.8	2.9	1.2		2.0
Other[7]	4.4	9.1		6.8	2.2	18.8		10.5	4.0	16.6		10.3
Unsaponifiable		8	6.8	7.4		14	18.2	16.1		17	18.4	17.7
Elemental												
K (potassium)	15	8.7	5.6	9.8	7.2	8.3	5.4	7.0	56	71	64	64
Na (sodium)	3.6	3.0	4.2	3.6	11	1.2	4.1	5.4	11	26	39	25
Ca (calcium)	19	10	18	16	24	23	44	30	20	22	20	21
Cu (copper)[8]	192	40	245	159	62	145	635	281	30	45	500	192
Pb (lead)[8]	0.12	<5	<5	<5	<0.1	<5	<5	<5	<0.1	<5	<5	<5
Hg (mercury)[8]	<0.7	<20	<20	<20	<0.7	<20	<20	<20	<0.7	<20	<20	<20
Cl (chloride)	2.1	1.5	1.4	1.7	0.88	1.7	1.0	1.19	9.9	17.5	25.7	17.7
S (sulfur)	2.3	1.8	2.6	2.2	2.0	3.0	4.1	3.0	3.1	9.8	19.2	12.9
P (phosphorus)	16.5	9.4	13.4	13.1	21.0	33.2	31.4	28.5	25.2	29.0	22.2	24.5
B (boron)[8]	24	12	12	16	17	16	16	16	25	16	68	36
As (arsenic)[8]	<1	<1	24	8	<1	<1	85	28	<1	<1	265	88
Se (selenium)[8]		<2	<2	<2		3	2	2		9	4	6

See footnotes at end of table 2.

TABLE 14.--Average chemical analyses of cattle and hog wastes calculated on a whole waste basis[1]

Analysis[2]	Cattle waste				Hog waste			
Group/specific	Fiber fraction	Particulate fraction	Soluble fraction	Whole waste	Fiber fraction	Particulate fraction	Soluble fraction	Whole waste
Standard waste								
Total solids[3]				468				315
Volatile solids				688				773
Ash				312				176
pH			6.65	6.6			6.2	6.15
Alkalinity[4]				0.26				0.22
COD			1196	795			1588	1049
BOD			263	166			536	345
Partition (per g whole)	550	315	134		454	463	83	
Carbohydrate								
Total neutral	184.8	76.9	10.2	271.9	181.1	109.3	7.6	298.0
Glucose	165.9	69.0	9.1	244.0	160.3	88.0	6.8	255.1
Galactose	6.6	2.8	0.3	9.7	7.3	5.1	0.3	12.7
Mannose	5.0	1.9	0.4	7.3	5.9	3.7	0.2	9.8
Xylose	5.5	1.9	0.3	7.7	5.0	3.2	0.1	8.3
Arabinose	2.8	0.9	0.1	3.8	2.7	1.4	0.2	4.3
Cellulose	122.6	41.0	0.8	164.4	108.1	57.4	0.6	166.1
Hemicellulose	19.8	7.9	1.2	28.9	20.9	13.4	0.6	34.9
Lignin	46.2	19.5		65.7	9.1	6.9		16.0
Phytic acid[5]	0.688	0.151	0.028	0.867	0.686	0.199	0.017	0.902
Total soluble saccharides	3.3	4.7	5.2	13.2	3.2	7.9	3.3	14.4
Glucose	1.6	2.2	3.5	7.3	1.4	3.7	2.0	7.1
Oligosaccharides	1.6	2.8	1.7	6.1	2.3	4.2	1.5	8.0
Nitrogen compounds								
Total Kjeldahl	10.80	10.17	7.56	28.53	12.85	20.33	7.00	38.56
Non-protein								
Urea			0.04	[6](0.04)			(0.01)	(0.01)
Ammonia			2.18	2.18			3.47	3.47
Nitrate			[7]-	-			-	-
Nitrite			-	-			-	-

Total amino acids	41.91	40.26	18.99	101.16	44.08	92.09	15.32	151.49
Alanine	4.84	4.03	4.27	13.14	3.81	7.68	1.73	13.22
Valine	2.53	2.46	1.06	6.05	2.86	5.79	1.06	9.71
Glycine	2.59	2.33	1.30	6.22	2.59	4.77	1.00	8.36
Isoleucine	2.04	2.14	0.86	5.04	2.41	5.28	0.90	8.59
Leucine	3.85	3.84	1.23	8.92	4.45	10.51	1.24	16.20
Proline	2.58	2.33	0.67	5.58	2.41	5.05	0.63	8.09
Threonine	1.82	1.67	0.82	4.31	2.36	4.03	0.81	7.20
Serine	1.65	1.45	0.60	3.70	1.82	3.89	0.59	6.30
Methionine	1.92	0.82	0.54	3.28	1.09	1.85	0.53	3.47
Hydroxyproline	0.38	0.13	0.05	0.56	0.45	0.28	0.04	0.77
Phenylalanine	2.09	2.08	0.79	4.96	2.36	5.23	0.72	8.31
Aspartic acid	3.80	3.72	1.77	9.29	4.40	8.80	1.68	14.88
Glutamic acid	7.70	7.97	2.75	18.42	6.67	14.82	2.12	23.61
Tyrosine	1.21	1.39	0.64	3.24	1.72	4.12	0.66	6.50
Lysine	2.58	1.95	0.91	5.44	2.50	4.72	1.02	8.24
Histidine	0.77	0.69	0.28	1.74	0.82	1.67	0.18	2.67
Arginine	1.26	1.07	0.38	2.71	1.32	3.19	0.39	4.90
Cystine	0.16	0.19	0.05	0.40	0.04	0.37	0.04	0.45
Free amino acids	2.92	1.51	3.86	8.29	3.31	3.38	3.32	10.01
Alanine	1.60	0.76	2.12	4.48	0.77	0.74	0.71	2.22
Valine	0.11	0.09	0.17	0.37	0.27	0.28	0.26	0.81
Glycine	0.22	0.13	0.28	0.63	0.23	0.23	0.17	0.63
Isoleucine	0.06	0.03	0.12	0.21	0.18	0.23	0.22	0.63
Leucine	0.11	0.06	0.13	0.30	0.27	0.32	0.27	0.86
Proline	0.06	0.03	0.09	0.18	0.18	0.23	0.18	0.59
Threonine	0.03	0.03	0.05	0.11	0.14	0.14	0.13	0.41
Serine	-	0.02	0.04	0.06	0.14	0.14	0.12	0.40
Methionine	0.06	0.03	0.03	0.12	0.09	0.14	0.12	0.35
Hydroxyproline	-	-	0.01	(0.01)	-	-	0.01	(0.01)
Phenylalanine	0.03	0.03	0.07	0.13	0.14	0.18	0.11	0.43
Aspartic acid	0.03	0.03	0.09	0.15	0.14	0.09	0.19	0.42
Glutamic acid	0.22	0.13	0.36	0.71	0.41	0.23	0.48	1.12
Tyrosine	0.06	0.03	0.08	0.17	0.18	0.14	0.12	0.44
Lysine	0.06	0.03	0.09	0.13	0.18	0.23	0.20	0.61
Histidine	0.03	0.02	0.05	0.10	0.04	-	0.02	0.06
Arginine	-	-	0.04	(0.04)	-	0.02	0.02	(0.04)
Cystine	-	-	-	-	-	-	-	-

See footnotes at end of table.

TABLE 14.--Average chemical analyses of cattle and hog wastes calculated on a whole waste basis--continued

Analysis[2]	Cattle waste				Hog waste			
Group/specific	Fiber fraction	Particulate fraction	Soluble fraction	Whole waste	Fiber fraction	Particulate fraction	Soluble fraction	Whole waste
Lipid								
Total	20.40	19.72	31.65	71.77	48.62	91.86	27.98	168.46
Total neutral	13.04	9.10	4.64	26.78	44.45	76.82	6.45	127.72
Myristic acid	0.22	0.20	0.08	0.50	0.41	0.69	0.04	1.14
Palmitic acid	1.54	1.26	0.62	3.42	6.95	13.80	0.79	21.54
Stearic acid	7.04	4.98	2.83	14.85	24.29	44.91	3.20	72.40
Unsaturated C_{18} acids	0.50	0.38	0.15	1.03	3.09	6.02	0.32	9.43
Glycerides								
Mono-	0.06	0.06	0.03	0.15	0.27	0.74	0.07	1.08
Di-	0.22	0.13	0.03	0.38	0.64	2.82	0.22	3.68
Tri-	0.11	0.13	0.03	0.27	1.50	4.07	0.17	5.74
Other[8]	3.08	2.14	0.86	6.08	3.09	4.86	0.85	8.80
Unsaponifiable	1.65	1.13	0.50	3.28	3.36	7.45	1.47	12.28
Elemental								
K (potassium)	6.0	3.2	8.8	18.0	4.45	3.24	5.31	13.00
Na (sodium)	3.80	1.23	5.36	10.39	1.63	2.50	2.08	6.21
Ca (calcium)	7.7	6.6	2.4	16.70	7.3	13.9	1.7	22.90
Cu (copper)[9]	16.5	18.9	4.0	39.4	72.2	130.1	15.9	218.2
Pb (lead)[9]	-	-	-	-	-	-	-	-
Hg (mercury)[9]	-	-	-	-	-	-	-	-
Cl (chloride)	3.68	1.58	10.01	15.27	0.77	0.55	1.47	2.79
S (sulfur)	1.48	1.20	1.27	3.95	1.00	1.39	1.07	3.46
P (phosphorus)	2.64	2.71	1.46	6.81	5.95	13.20	2.03	21.18
B (boron)[9]	13.8	8.8	5.1	27.7	7.3	7.4	3.0	17.7
As (arsenic)[9]	-	0.3	0.1	(0.4)	3.6	13.0	7.3	23.9
Se (selenium)[9]	-	-	0.3	(0.3)	-	0.9	0.5	(1.4)
Total accounted for				838.8				826.6

[1]Calculated from averages for fractions in Tables 12 and 13. [2]Analyses: mg/g dry wt. of whole waste except as noted. [3]Total solids: mg/g wet wt. [4]Alkalinity: ml of 1N HCl or NaOH required to neutralize 2 g dry wt. of waste. [5]Phytic acid: reported as mg inositol/g dry wt. [6]Calculated values in ( ) below detectable limit of analysis if whole waste were analyzed. [7]Value below detectable limit. [8]Other (neutral lipid): unidentified components eluting after the monoglycerides and before the diglycerides. [9]Cu, Pb, Hg, B, As, Se: µg/g dry wt.

tributable to the relative proportions of the fractions in the original waste. Only 8.3 percent of the hog waste solids were in the soluble portion, the remainder being divided equally between the fiber and particulate fractions. In cattle feedlot waste (FLW), the soluble fraction contained 13.4 percent of the dry weight solids with the remainder divided 5 to 3 between the 55 percent in fiber and 31.5 percent in particulate fractions. When compared with the FLW average, the AP (pristine samples from Feedlot A) and G samples (Feedlot G) partitioned to give larger fiber and soluble fractions at the expense of the particulate fraction.

Samples from the Southwestern feedlots had higher than average fiber contents but contained subnormal amounts of solubles. These samples also differed from FLW averages by having higher values for pH and total solids (with normal ash content). Lignin was high in both fiber and particulate fractions; total lipid, but not neutral lipid was high in the particulate fraction. Total Kjeldahl and total amino acids were high in the particulate fraction but low in the soluble fraction reflecting the shift in partitioning of waste into the three fractions. These changes show the composite effects of weather, sample age, and diet.

Standard waste analyses

The values for total and volatile solids, pH, alkalinity, and COD showed wide variations. This may be attributed to variations in environment, age of samples collected, and feedlot practices.

Total and volatile solids, ash, and pH.—At 31.5 percent, the average total solids in hog waste was two-thirds that of FLW. FLW had an average ash content of 312 mg/g dry wt, almost double that of hog waste, and a proportionally lower volatile solids content. The pH of FLW and hog waste samples averaged 6.6 and 6.1. These differences between cattle and hog wastes resulted largely from feedlot conditions. Dirt admixture and liquid loss into the dirt were minimal in pristine (AP) FLW samples from Feedlot A and those from Feedlot G, with cement-floored pens. These samples gave results similar to those of hog waste.

Alkalinity, BOD, and COD.—Average alkalinities of the two wastes were similar although the variability among FLW samples was twice that of hog waste samples. The average COD of hog waste was one-third higher than the 800 average for FLW and the average hog waste BOD was double the 166 average for FLW. Although above the average for FLW samples, the COD and BOD of the AP and G feedlot samples did not approach the values obtained for hog waste samples.

Carbohydrate

Carbohydrates and lignin accounted for 35.2 percent of dry weight FLW and 32.9 percent of hog waste. Cellulose and hemicellulose constituted 16.4 and 3 percent of FLW and 70 percent of the total neutral carbohydrates. The fiber fractions contained three times the amount of cellulose and hemicellulose present in particulate fractions. There were only slight amounts in the solubles. Lignin accounted for 6.6 percent of FLW and was distributed 2:1 between fiber and particulates. The soluble saccharides (1.3 percent of total carbohydrate) were equally divided among the three fractions, as was the 0.1 percent phytic acid. There was no difference between the A and AP samples from Feedlot A.

Hog waste contained slightly more carbohydrate of all types but less lignin than did FLW. The 1.6 percent lignin present in hog waste was evenly divided between the fiber and particulates, reflecting the comparatively large particulate fraction in hog waste.

Nitrogen compounds

Total Kjeldahl nitrogen.—Neither seasonal variation nor location affected the total nitrogen content. Cattle waste averaged 2.85 percent total nitrogen on a dry weight basis. A and AP samples from Feedlot A were alike. Only samples from Feedlots E and H were below average and they had unusually high ash and low total volatiles contents. In general, higher ammonia content was offset by lower total amino acid content. Total nitrogen in the waste decreased as roughage in the diet was replaced with high energy grains with a concomitant shift of nitrogen from the fiber and particulate fractions to the soluble fraction. The soluble fraction, 13.4 percent of the total dry weight, contained 26.5 percent of the total nitrogen; the remainder was almost evenly divided between fiber and particulates.

Hog waste averaged 3.85 percent total nitrogen on a dry weight basis. As with cattle waste, the small soluble fraction (8.3 percent of the total dry weight) contained a disproportionate 18.2 percent of the nitrogen. About half of the total nitrogen was in the particulate fraction, the remaining third in the fiber.

Total and free amino acids.—Total amino acids

represented one tenth of the dry matter in cattle waste. They were divided approximately 2:2:1 among the fiber, particulate, and soluble fractions. Individual amino acids, except alanine, were distributed in the same manner. Lysine and methionine were present in relatively high amounts representing 5.4 and 3.3 percent of the total amino acids. Alanine, 13 percent of the total protein, was equally divided among the three fractions. Eight percent of the total amino acids were free amino acids and these were divided approximately 2:1:3 among the fiber, particulate, and soluble fractions. By weight, half of the free amino acid content was alanine. There was no apparent correlation between ammonia and alanine levels in the soluble fractions.

Degradation of protein in FLW occurred with age. The total amino acid content of fresh (AP) samples was 10 percent greater than that of older surface (A) samples. One half of this difference was in the soluble fraction where the total amino acid content of fresh samples was 50 percent higher than in surface samples. In addition, the free amino acid content of the soluble fraction of aged waste was twice that of the pristine.

In general, FLW from animals on high roughage diets had higher total amino acid content than those on high energy grain diets. However, both the total and the free amino acid content of the soluble fraction were lower.

Total amino acids represented 15 percent of hog waste on a dry weight basis. They were divided approximately 3:6:1 among the fiber, particulate, and soluble fractions. Individual amino acids were partitioned similarly. Lysine and methionine, at 5.4 and 2.3 percent of the total amino acids, were present in respectable amounts. One percent of dried hog waste—6.7 percent of the total amino acids—was free amino acids. They partitioned evenly among the three fractions. By weight 20 percent of the free amino acid content was alanine.

Although the total amino acid content of both wastes is large, the determined values may be low because of the clean-up procedure required for analysis. About one-third of the Kjeldahl nitrogen is not accounted for by the specific components measured and is partitioned among the fiber, particulates, and solubles in about the same proportions as the total amino acids.

Non-protein nitrogen.—Determination of these compounds was carried out only on the soluble fraction. Ammonia constituted about 25 percent of the Kjeldahl nitrogen in the soluble fraction and represented 0.2 and 0.3 percent of dry weight FLW and hog waste. Urea was present at less than 0.01 percent and nitrate and nitrite were not detected.

Lipid

FLW contained 7.2 percent total lipid; 44 percent was in the soluble fraction with the remainder evenly divided between fiber and particulates. Neutral lipids, 37 percent of the total lipids, represented 2.7 percent of the FLW dry weight. They were distributed approximately 3:2:1 among the fiber, particulate, and soluble fractions. Over half of the neutral lipid in each fraction was stearic acid and less than 1 percent existed as glycerides. The difference between total and neutral lipids, 4.7 percent of the FLW dry weight, was probably volatile fatty acids; 60 percent of this difference was in the soluble fraction.

Total lipid content of fresh waste, 12 percent of the dry weight of AP samples, was twice that of the surface waste (A samples) from Feedlot A. Neutral lipid was less affected by aging, representing 4 and 3 percent of the dry weights of the AP and A samples. The assumed loss of volatile fatty acids was largely from the fiber fraction. No apparent correlation existed between diet and lipid content of FLW.

Hog waste contained 16.8 percent total lipid; 16.6 percent was in the soluble fraction with the remainder divided 1:2 between fiber and particulates. Neutral lipids, three-fourths of the total lipids, represented 12.7 percent of the hog waste dry weight. Sixty percent was in the particulate fraction and 5 percent in the solubles. Proportionally, stearic acid and glycerides were the same as in FLW. The assumed volatile fatty acids (total lipid minus neutral lipid) was 4 percent of the hog waste solids, half in the soluble fraction.

Elemental

Attaching any specific correlations to these values either with respect to seasonal changes or to various feedlots is difficult because most of the manure samples contained a considerable percentage of dirt from the feedlot. Most prominent among these constituents were, as one would expect, Na, Cl, K, and Ca and to a minor extent S and P. Except the As and Cu levels in the spring 1972 sample from hog Feedlot F, the rest of the inorganic components were present in negligible quantities.

Nucleic acids and their components

DNA, RNA, and purine-pyrimidines.—DNA was measured in the cell-containing fiber and particulate fractions of the A and AP samples, using large

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(15 to 25 g) amounts of lyophilized sample. We expected that RNA could be determined during the DNA procedure, as is frequently done. However, interferences gave RNA results which were suspect. Therefore, the procedure given, employing more extensive cleanup and detection by ultraviolet absorption rather than by ribose measurement was used.

By making this change, sensitivity was lost but detection via the base moiety eliminates those interferences from substances that react similarly to ribose. Cleanup procedures were a composite of many methods for nucleic acid determination in diverse materials. This revised method did not affect the determination of DNA because both nucleic acids are isolated and determined in tandem to the point of alkaline digestion and reprecipitation of DNA.

Because of the complexity of the procedures, only the A and AP samples of the first collection were examined. The DNA content of the fiber fractions was 0.24 mg/g dry wt of the AP sample and 0.08 mg/g dry wt of the A sample. Similarly, in the particulate fractions the DNA content of the pristine (AP) sample was substantially higher than standard (A) sample at 0.41 and 0.11 mg/g dry wt respectively. RNA was not detected in these samples and was therefore less than 3.4 mg/g dry wt of the fractions. The percent of purine-pyrimidines was measured in these samples and in the corresponding soluble fractions. Again positive samples contained larger amounts of the nitrogen bases in all fractions. The fiber, particulate, and soluble fractions of AP sample contained 2.8, 1.8, and 6.7 mg/g dry wt of fraction; corresponding amounts in the A fractions were 0.15, 0.14, and 2.3 mg/g dry wt of fraction.

Free bases, nucleosides and nucleotides.—Uncombined or free nucleotides, purines, and pyrimidines present in both pristine (AP) and surface (A) wastes taken from Feedlot A were determined in the soluble fractions from all three collections. Trace amounts of free nucleotides may be present in the fiber and particulate fractions due to incomplete fractionation and entrapment; the amounts should be negligible. The identifications are tentative and the quantitative data is dependent upon the correctness of these identifications. Ultraviolet, infrared, nuclearmagnetic resonance or mass spectrometry on the fractionated eluants from the liquid chromatograph would be required for complete verification (*13, 24, 32*).

The quantities of bases and nucleosides present were surprisingly consistent from one collection to the next and from pristine to surface wastes. Excepting adenine, the higher values occurred in the pristine (AP) samples. Uracil, adenine, and guanosine appeared in substantially greater amounts than the other common bases and nucleosides. Those compounds present in trace quantities, but in amounts less than the established detection limit, are shown by the letter t (trace) after the sensitivity figure. Trace quantities are indicated if they were obtained in at least one of the three samples analyzed. The average results are expressed in milligrams of compounds per gram of soluble fraction on a dry weight basis. Adenine, guanine, cytosine, and uracil contents of AP solubles were 0.5, 0.1, 0.4, and 3.1; corresponding values for A solubles were 1.8, 0.06, 0.3, and 2.5. The nucleoside contents of AP solubles were $<$0.1-t, 1.4, 0.4, and $<$1 for adenosine, guanosine, cytidine, and uridine; values for the A solubles, in the same order were $<$0.1-t, 0.9, $<$0.2-t, and $<$1.

Only small quantities of monophosphate nucleotides were found although some peaks remained unidentified. The di- and triphosphate nucleotides showed less consistency than the other classes of compounds studied, but there were substantial amounts of 5′ UTP[4] present, especially in the surface waste (A) samples.

Examination of retention times for the peaks from samples versus those of the pure nucleotide standards revealed deviations greater than $\pm$ 5 percent in some cases. These identifications are more suspect than those of the bases and nucleosides, and are enclosed in parentheses even if they were observed in only one of the three samples analyzed. As above, average results are expressed in milligrams of compound per gram of soluble fraction on a dry weight basis and trace quantities are indicated. In the AP samples only 5′ AMP and 5′ GMP were recovered at 0.5 and 0.6 levels; traces, $<$0.5-t, of 2′ AMP, 2′ or 3′ GMP, 5′ CMP, and 2′ UMP were detected; other monophosphate nucleotides were not detected, $<$0.05. In the A samples 2′, 3′, and 5′ AMP levels averaged 0.5, 0.6, and 0.7 respectively; 2′ or 3′ GMP was (1.4) and 5′ GMP averaged 0.9. Traces, $<$0.5-5, of 2′ CMP, 2′ UMP, and 3′ UMP were detected but 3′ CMP, 5′ CMP, and 5′ UMP were not, $<$0.5. Retention times of 2′ or 3′

[4] Abbreviations for nucleotides—AMP, ADP, ATP: adenosine mono-, di-, triphosphate; CMP, CDP, CTP: cytidine mono-, di-, triphosphate; GMP, GDP, GTP: guanosine mono-, di-, triphosphate; UMP, UDP, UTP: uridine mono-, di-, triphosphate. 2′, 3′, 5′: nucleoside (ribose) carbon to which phosphate(s) are attached.

GMP and 2′ UMP samples deviated by more than 5 percent from the standards.

5′ ADP was the only diphosphate nucleotide detected and 5′ ATP was the only triphosphate nucleotide not detected. AP solubles contained (0.5), 3.7, (0.9), and (2.5) levels of 5′ ADP, 5′ GTP, 5′ CTP, and 5′ UTP respectively; corresponding values for A solubles were 1.1, 2.7, 4.8, and 8.2. Detection limits for 5′ GDP, 5′ UDP, and 5′ ATP were 0.5 and that of 5′ CDP was 1.0. Retention times of only one or two of the six samples tested for 5′ ADP, 5′ CTP, and 5′ UTP varied by more than 5 percent from the respective standards.

MICROBIAL ANALYSES

Feedlots and Sampling

Feedlots A to I

Characteristics of Feedlots A to I and sampling methods are given in the first section of this report (table 1).

Feedlot J

A 5,000 to 10,000 head beef cattle feedlot in Illinois, Feedlot J occupies about 50 acres of a 1,400-acre integrated farm; associated cropland was planted to corn. The feedlot, sampling sites, and method of sampling are defined in detail in Rhodes and Hrubant (*36*). Briefly, the samples were collected as follows every other month.

Feedlot waste samples.—Twelve 3- to 5-g portions were collected randomly from the concrete portion of the floor of two pens for each sample.

Runoff samples.—Approximately 100-ml samples were collected by multiple subsurface dipping from a ditch adjacent to the pens.

Associated site samples.—Each site was sampled once. Some samples were composites of three to four core samples each 15 to 20 cm deep. A field, spread with FLW the previous winter was core sampled in March and September, before and after corn was planted. Pen dirt, the elevated soil area in the pens, was also core sampled. The stockpile cores were obtained from a field site free of vegetation that was used for years for storage of FLW. The composted FLW was 0.5 to 1 m deep. The feed sample was a composite of twelve 3- to 5-g portions from the feed trough of the pens sampled for FLW. The field ditch, which drained the fields and received the runoff from the pens, was sampled by multiple subsurface dip. All samples were immediately cooled by covering the containers with cracked ice and transported to the laboratory in an ice chest.

Materials and Methods

Microbial counts

One-gram refrigerated manure samples from Feedlots A-I were used at Denver Research Institute (DRI). Serial dilutions were prepared in sterile water blanks. Total aerobic microbial counts (wet weight) were determined by spread plating 0.3 ml of appropriate dilutions on Eugon agar (BBL, Division of BioQuest, Cockeysville, Md.) plates. Plates were incubated for 48 h at 35° C, counted, and airmailed to the Northern Regional Research Center. Total aerobic microbial counts (dry weight) were calculated using total solid values given in the chemical analyses.

All samples from Feedlot J were prepared for plating by serial dilution in 0.1 percent tryptone (Difco Laboratories, Detroit, Mich.). A 10 ml portion of liquid samples was used to give the initial 1:10 dilution. FLW and solid samples were weighed in entirety (30 to 50 g/sample) and mixed in a Waring Blendor with sufficient sterile water to make a 1:4 dilution (w/v). A 40-ml portion of the 1:4 dilution was diluted with 60 ml 0.1 percent tryptone to make the initial 1:10 dilution. Enumeration of selected groups of organisms was done by spread plating 0.3 ml of appropriate dilutions onto previously prepared plates. Plating was completed within 5 h of collection. All plates were incubated at 28° to 30° C.

Total aerobes were counted on Eugon agar after 2 days of incubation. Yeasts and fungi, differentiated by colony appearance, were counted on Mycophil agar (BBL) containing 0.2 mg of dihydrostreptomycin sulfate and 330 units of penicillin G per ml after 3 days of incubation. Streptomycetes were counted on the starch-salts agar of Pridham and others (*35*) containing 0.5 mg cycloheximide per ml after 7 days of incubation. Dry weights of FLW samples were determined and used to calculate total aerobic counts per dry gram FLW.

Selection of typical colonies

Isolates were selected by colony type from the three replicates of the countable plates. The percent of the total aerobic count or the total yeast count represented by each colony type was estimated and recorded by increments of 10 (1 percent:

any value <10 percent; 10 percent: ≥ 10 percent but <20 percent; 20 percent: ≥ 20 percent but <30 percent; and so forth). Low numbers of fungi and streptomycetes generally precluded estimating the percent of these organisms.

Isolated colonies of each apparent type were selected from plates of the countable dilution or the next higher dilution, transferred to agar slants of appropriate media, incubated at 28° C for 1 to 7 days, and stored at 4°. Media used for isolates were Eugon agar for total aerobes and yeasts; peptone-malt extract-glucose agar, formulation M48 (*43*), for fungi; and starch-salts agar for streptomycetes.

Characterization of isolates

Inocula and morphology.—All subcultures were incubated at 28° C. Total aerobic isolates were transferred to Eugon agar slants and incubated 1 to 2 days. Yeast isolates were transferred to yeast-malt (YM) agar slants, formulation M69 (*42*) and incubated 3 days. Growth from the slants was suspended in water for use as inoculum for biochemical tests and for Gram reaction (Hucker modification) according to procedures given in "Manual of Microbiological Methods" (*41*). If microscopic examination revealed a mixed culture, it was restreaked on Eugon (total aerobes) or YM (yeasts) agar. The cell type that was dominant by microscopy was selected and treated as an original isolate.

Fungi, including macroscopically filamentous yeasts, were transferred to paired peptone-malt extract-glucose agar plates. One plate was used for identification by colonial morphology and microscopic observation. The second, after 7 days incubation, provided the inoculum for zein, starch, cellulose, and lipid degradation tests.

Streptomycetes were streaked on starch-salts plates and incubated 7 days. Resultant growth was used as inoculum for the four degradative tests.

Biochemical tests.—Media and procedures in Ewing and Davis (*21*) were used for the following tests: urease (Stuart and Christensen); nitrate reduction; motility, hydrogen sulfide, and indol (Kovac's) on SIM. All tests were incubated at 28° C except urease, which was done at 37°. Inoculated litmus milk (BBL) was also incubated at 28°; results were observed at 3 and 10 days.

The basal medium for zein and starch hydrolysis, lipase production, and cellulose digestion was 0.7 percent tryptone, 0.5 percent sodium chloride, 0.3 percent yeast extract, and 2 percent agar (all Difco). For zein hydrolysis, a solution of 2.5 percent zein (Sigma Chemical Co., St. Louis, Mo.) in 80 percent ethanol was rapidly pipetted into hot basal agar to give an 0.1-percent zein concentration, and the medium was then autoclaved for 10 min. Plates were streaked and incubated for 7 days at 28° C. Hydrolysis was indicated by a clearing of insoluble zein in the medium surrounding the growth.

For starch hydrolysis, 1-percent soluble starch (Difco) was added to the basal medium. Plates were incubated for 7 days at 28° C before flooding with iodine to detect hydrolysis.

For cellulose digestion, a strip of Whatman No. 1 filter paper was added to the basal medium without agar. The inoculated tubes were incubated for 30 days at 28° C.

A modification of Alford and Steinle's (*1*) double-layer plate method was used to test lipase production. An emulsion layer containing 1.25-percent corn oil and 10 percent of a 1:1,500 solution of Victoria blue B was used under the basal nutrient layer.

The basal medium for zein and starch hydrolysis, without the agar, was also used for acid production from carbohydrates. Phenol red (0.0018 percent) and 0.5 percent glucose, lactose, or xylose were incorporated in the basal medium before autoclaving. Durham tubes were used in the glucose medium to detect gas production. Tests were observed after 1, 2, and 3 day's incubation at 28° C.

Salmonella detection

Fecal samples from Feedlots A-I were examined at DRI. Methods were based on reports by Cheng and others (*16*), Dunn and Martin (*19*), and Sharma and Packer (*37*). Whole waste samples were diluted with sufficient sterile water to impart liquid consistency. Water samples containing *Salmonella typhimurium* were used as a positive control with the waste samples. Slurries (1.0 ml) were enriched in Brilliant Green MacConkey broth (Difco) and Tetrathionate broth (Difco). A 7-mm loopful from positive enrichments were streaked onto Brilliant Green Sulfa agar (Difco) and Brilliant Green Neutral Red Lactose agar (Difco). Suspect colonies were restreaked on duplicate agar plates and Triple Sugar Iron (TSI) agar slants were streaked and stabbed. TSI slants which showed acid or acid and gas butt, alkaline slant, and hydrogen sulfide production were tested biochemically using Auxotab Enteric 1 cards (Colab). Suspect colonies were also checked for motility (hanging drop) and tested serologically using pooled H-antiserum (Difco) with cells grown in M-broth (Difco).

The enterobacteria in FLW and runoff from Feedlot J have been reported (*28*). One composite FLW sample from 2 pens, 10 fresh samples from 7 other pens, and runoff and field ditch waters were examined. Samples were enriched in selenite cystine broth (BBL) and streaked on both bismuth sulfite agar (BBL) and *Salmonella*-Shigella agar (BBL). Six to 10 isolates from each plate were examined biochemically. Suspect isolates were serotyped with Polyvalent O, Group A, B, C_1, C_2, D, E, and Vi antisera (Difco).

Antibiotic detection

AOAC procedures were used to detect levels of chlortetracycline (*9*) and (*10*) in selected waste samples. FLW (10 g samples) from the first two collections from Feedlots A (A and AP samples) and E were analyzed for chlortetracycline. The first sample from hog Feedlot I was examined for furazolidone.

Results and Discussion

Four cattle or hog waste samples each from Feedlots A to I were examined for aerobic microorganisms. Three of the four samples were those analyzed chemically and feedlot conditions in table 1 apply to these samples. Seven waste and runoff samples together with six samples from sites associated with waste from cattle Feedlot J in Illinois were examined for total aerobes, streptomycetes, yeasts, and fungi. Conditions at this feedlot are in Rhodes and Hrubant (*36*).

Each sample was analyzed for total aerobic microbial count (tables 15 and 16) and percent distribution of dominant aerobic types based on their microscopic appearance (tables 17 to 24) together with their biochemical capabilities (referenced in table 25). The profile of the 15 microscopic groups present in all samples is summarized in table 26; and, the profile of degradative capabilities of all aerobic isolates is summarized by microscopic group and by source in table 27. The biochemical capabilities and distribution of streptomycetes, yeasts, and fungi in all samples from Feedlot J are given in tables 28, 29, and 30.

Salmonella and antibiotic detection are also discussed.

Microbial counts in cattle feedlot waste

The log number of total aerobic microorganisms in cattle feedlot waste (FLW) varied from 7.0 to 10.4 organisms/g wet wt FLW with an average of 8.6 organisms/g wet wt for 28 FLW samples that were collected at 4 different times from 7 feedlots (table 15). On a dry weight basis the log number of organisms was 9.1 $\pm$ 1.5 organisms/g dry wt FLW, averaging only the first three collections above—wet wt equivalents were 8.8 organisms/g FLW with a range of 7.4 to 10.4 organisms/g FLW.

Counts in samples from Feedlot D, in Kansas, were consistently above the collection averages and those from Feedlot A, in Colorado, consistently below in all four sampling periods; however, in no instance did either represent the maximum or minimum count obtained for the sampling time. Feedlot J, sampled separately seven times, gave the highest average total aerobic count with little variability between samples (table 16). The log number of total aerobic microorganisms varied from 8.8 to 10.2 organisms/g wet wt FLW, averaging 9.7 organisms/g, and 9.4 to 10.7 organisms/g dry wt FLW, averaging 10.2 organisms/g. The low numbers in the January samples accounted for more than half of the 1.4 log number variation in the seven samples.

No correlation, direct or inverse, was apparent between changes in the microbial population with variation in any of the chemical analyses presented in tables 2-14. Further, changes in the microbial population were not correlated with altered practices or conditions of the various feedlots (table 1) except the use of antibiotics.

Two factors were related to variation in total counts—sampling procedure and use of aureomycin in feed. Consistently high counts were attained when larger aliquots of the waste samples were used; this reduced the limitations inherent in small waste samples of the mixed types (dryness, soil content, and so forth) taken from the feedlots as representative. Also, the shorter the time from sampling to plating, the more uniform the counts were.

The range in log numbers of organisms in samples from Feedlots A and J was 1.4; those in samples from Feedlots B, C, and G were between 2.7 and 3.2. Samples from Feedlots A and J were plated within 24 h of collection; those from Feedlots B, C, and G were plated 2 to 5 days after collection. The high log number counts of 9.8 to 10.4 organisms/g wet wt obtained in Feedlots B, C, and G were most representative because they were like those obtained from Feedlot J; and lower counts resulted from delay necessitated by shipping.

Aureomycin was included in the feed used on Feedlot D and E, in one sample from Feedlot G, and probably was present in most samples from Feedlot A (table 1). Presence of aureomycin was a factor in stabilizing counts from these feedlots. The

variations in the log number of organisms/g wet wt in samples from Feedlots D and E were 0.9 and 1.3. Although higher average counts were obtained from these feedlots, maximum log number counts were approximately 0.3 log unit lower than those for feedlots not using antibiotics. The use of combiotic at Feedlot H did not have the same stabilizing effect on the total counts.

Distribution of types of aerobes in feedlot waste

In tables 17 to 24, recovery of most numerous aerobes frequently was less than 90 percent (sum of percent distribution in the total numbers). This resulted from the estimating procedure used. The percent of different colony types estimated on the countable plates was not adjusted if the organisms from a given colony type did not grow on isolation in spite of repeated efforts. Thus, no characterization data was obtained for the organisms in these colony types, and totals were less than data from plate counts would indicate. In addition, two samples contained no dominant colony types; all of the colony types were between 1 and 10 percent. Therefore, the percent composition after isolation and characterization was under 10 percent of the total.

The aerobes were divided into 15 groups based on microscopic appearance (table 26). Four of these groups dominate the populations of FLW: group 1- G^+ or G^v rods, diphtheroids; group 2- G^v irregular rods; ovoid and coccoid forms, granular; group 5- G^+ small rods, single; and group 7- G^- small rods, single.

In FLW samples from feedlots not using antibiotics (Feedlots B, C, G, and J), the irregularly shaped rods of groups 1 and 2 were predominant with substantial numbers of groups 5 and 7. Of these aerobic populations, 50 to 90 percent were types in groups 1 and 2. One diphtheroid, group 1-biochemical type 1 (table 25), was characteristically present as 10 to 70 percent of the total population in these samples. The organism has been characterized (*27*). Dominance of this organism correlated with high total populations. Other biochemical types in groups 1 and 2 occurred randomly.

The small single rods of groups 5 and 7 commonly occurred in lesser numbers in all samples. Presumed coliforms, group 7-biochemical types 7, 20 to 27, and 30, totaled less than 10 percent of populations in samples containing high total numbers. Samples which yielded low total aerobic populations were characterized by a low percentage (or absence) of group 1-biochemical type 1, by approximately equal populations of groups 1 and 2 versus groups 5 and 7, and usually by the presence of significant numbers of presumed coliforms or organisms from other groups.

In FLW samples from feedlots using aureomycin or combiotic (Feedlots A, D, E, and H), the small single rods of groups 5 and 7 usually were predominant with substantial numbers of groups 1 and 2. The difference in population makeup was primarily the absence of the one diphtheroid, group 1-biochemical type 1. This diphtheroid was present in some samples from these feedlots. Aureomycin was fed for the first 30 days only to new animals on Feedlot A and was fed to animals when sick on Feedlot D. Again, samples with low total aerobic populations were characterized by significant numbers of presumed coliforms and organisms from other groups.

Aerobic microorganisms in hog waste

The log number of total aerobic microorganisms in eight hog waste samples varied from 6.8 to >10.0 organisms/g wet wt waste with an average of 8.2 organisms/g wet wt. The dry weight average for the first three collections was 8.6 organisms/g dry wt waste with a range of 7.2 to >10.5 organisms/g dry wt waste; the equivalent wet weight average was 8.0 organisms/g waste.

As with FLW, no apparent correlation existed between changes in population and chemical composition or feedlot conditions; again the use of antibiotics and sampling procedure influenced microbial counts. The greater variation in total aerobic population in samples from Feedlot F compared to Feedlot I probably resulted from the greater delay between sampling and plating. Differences between the two feedlots in average counts and range of counts may be caused by the use of different antibiotics. Because no antibiotic-free sample was examined, these assumptions are based on analogy with FLW samples. No pattern of dominant groups of aerobes was obtained from the six samples studied. The single, G^- small rods of group 7 were present in five of the six samples. No other group of organisms appeared in more than half the sample and only the G^+ large rods in group 4 appeared in significant numbers in at least three samples. The dominant group of organisms was different in each sample, and in only two instances were these groups present in a second sample in significant numbers. Moreover, the same biochemical type within each group was rarely isolated from two samples.

Text continues on page 90.

TABLE 15.--Total aerobic microbial counts of wastes from Feedlots A - I

Feedlot[1]	Log No. organisms/g wet wt. sample					Log No. organisms/g dry wt. sample				
	1[2]	2	3	4	Av.	1	2	3	4	Av.
					Cattle Waste - Pristine					
AP	9.1	8.5	7.6	8.0	8.3	9.7	9.1	8.3		9.0
					Cattle Waste					
A	8.9	8.8	7.5	7.6	8.2	9.0	9.3	7.8		8.7
B	10.2	9.1	7.9	7.6	8.7	10.3	9.3	8.0		9.2
C	7.4	10.4	7.5	8.3	8.4	7.6	10.6	7.6		8.6
D	9.6	9.7	8.8	9.3	9.4	10.0	10.2	9.0		9.7
E	9.6	8.3	8.6	8.4	8.7	10.0	8.7	8.8		9.2
G	8.5	9.8	8.6	7.1	8.5	8.8	10.4	9.0		9.4
H	9.7	7.7	9.3	7.0	8.4	10.2	8.3	9.6		9.4
Average cattle	9.1	9.1	8.3	7.9	8.6	9.4	9.5	8.5		9.1
					Hog Waste					
F	>10.0	9.6	7.0	8.7	8.8	>10.5	10.1	7.7		9.4
I	6.8	6.9	7.9	8.9	7.6	7.2	7.4	8.4		7.7
Average hog	8.4	8.2	7.4	8.8	8.2	8.8	8.8	8.0		8.6

[1]Conditions at time of sampling in Table 1. [2]Collection time of samples: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 16.--Microbial counts of feedlot waste, runoff, and associated site samples from cattle Feedlot J[1]

Microbial group	Log No. organisms/g wet wt. or /ml sample								Log No. organisms/g dry wt. sample							
	1[2]	2	3	4	5	6	7	Av.	1	2	3	4	5	6	7	Av.
Feedlot Waste																
Total aerobic	10.2	10.0	8.8	9.6	9.6	9.8	9.6	9.7	10.7	10.5	9.4	10.2	10.1	10.4	10.2	10.2
Yeasts	6.0	6.3	5.6	5.3	6.4	4.8	5.6	6.6	6.6	6.7	6.0	5.9	6.9	5.4	6.2	6.2
Fungi	5.0	5.4	4.5	4.7	4.0	4.9	5.6	4.9	5.6	5.9	4.8	5.3	4.5	5.4	6.2	5.4
Streptomycetes		2.8	4.4	3.9	5.1	6.1	5.8	4.7		3.3	5.0	4.5	5.5	6.7	6.4	5.2
Runoff																
Total aerobic	8.6	7.2	7.7	8.0	7.7	7.8	7.8	7.8								
Yeasts	4.6	3.6	4.2	3.5	4.3	4.7	4.3	4.2								
Fungi	3.6	3.0	3.4	2.1	<2.0	2.6	4.8	3.1								
Streptomycetes		3.4	4.8	4.0	6.5	5.1	5.0	4.8								

Associated Sites[3]

	Fd	Sp	FM	PD	FD	FS	Fd	Sp	FM	PD	FS
Total aerobic	9.7	8.2	9.1	8.8	6.9	7.7	9.9	8.7	9.6	9.0	8.1
Yeasts	8.1	5.7	6.1	4.1	3.5	4.5	8.3	6.1	6.6	4.3	4.9
Fungi	6.5	6.1	4.9	3.5	<2.0	5.0	6.6	6.6	5.7	3.7	5.5
Streptomycetes	2.5	6.8	6.5	7.4	4.0	7.2	2.7	7.4	6.9	7.6	7.6

[1]Description of 5,000-10,000 head cattle feedlot in Illinois in Microbiological Materials and Methods section. [2]Collection time of samples: 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971; 7, Sept 1971. Samples from associated sites collected at times indicated for waste samples in same column. [3]Associated site samples: Fd = feed from trough; Sp = stockpiled (old) FLW; FM = field (Mar)*; PD = pen dirt; FD = field ditch; FS = field (Sept)*. *FLW spread on field previous winter.

TABLE 15.--Total aerobic microbial counts of wastes from Feedlots A - I

Feedlot [1]	Log No. organisms/g wet wt. sample					Log No. organisms/g dry wt. sample				
	1[2]	2	3	4	Av.	1	2	3	4	Av.
				Cattle Waste - Pristine						
AP	9.1	8.5	7.6	8.0	8.3	9.7	9.1	8.3		9.0
				Cattle Waste						
A	8.9	8.8	7.5	7.6	8.2	9.0	9.3	7.8		8.7
B	10.2	9.1	7.9	7.6	8.7	10.3	9.3	8.0		9.2
C	7.4	10.4	7.5	8.3	8.4	7.6	10.6	7.6		8.6
D	9.6	9.7	8.8	9.3	9.4	10.0	10.2	9.0		9.7
E	9.6	8.3	8.6	8.4	8.7	10.0	8.7	8.8		9.2
G	8.5	9.8	8.6	7.1	8.5	8.8	10.4	9.0		9.4
H	9.7	7.7	9.3	7.0	8.4	10.2	8.3	9.6		9.4
Average cattle	9.1	9.1	8.3	7.9	8.6	9.4	9.5	8.5		9.1
				Hog Waste						
F	>10.0	9.6	7.0	8.7	8.8	>10.5	10.1	7.7		9.4
I	6.8	6.9	7.9	8.9	7.6	7.2	7.4	8.4		7.7
Average hog	8.4	8.2	7.4	8.8	8.2	8.8	8.8	8.0		8.6

[1]Conditions at time of sampling in Table 1. [2]Collection time of samples: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 16.--Microbial counts of feedlot waste, runoff, and associated site samples from cattle Feedlot J[1]

Microbial group	Log No. organisms/g wet wt. or /ml sample								Log No. organisms/g dry wt. sample							
	1[2]	2	3	4	5	6	7	Av.	1	2	3	4	5	6	7	Av.
Feedlot Waste																
Total aerobic	10.2	10.0	8.8	9.6	9.6	9.8	9.6	9.7	10.7	10.5	9.4	10.2	10.1	10.4	10.2	10.2
Yeasts	6.0	6.3	5.6	5.3	6.4	4.8	5.6	6.6	6.6	6.7	6.0	5.9	6.9	5.4	6.2	6.2
Fungi	5.0	5.4	4.5	4.7	4.0	4.9	5.6	4.9	5.6	5.9	4.8	5.3	4.5	5.4	6.2	5.4
Streptomycetes		2.8	4.4	3.9	5.1	6.1	5.8	4.7		3.3	5.0	4.5	5.5	6.7	6.4	5.2
Runoff																
Total aerobic	8.6	7.2	7.7	8.0	7.7	7.8	7.8	7.8								
Yeasts	4.6	3.6	4.2	3.5	4.3	4.7	4.3	4.2								
Fungi	3.6	3.0	3.4	2.1	<2.0	2.6	4.8	3.1								
Streptomycetes		3.4	4.8	4.0	6.5	5.1	5.0	4.8								

Associated Sites[3]

	Fd	Sp	FM	PD	FD	FS	Fd	Sp	FM	PD	FS
Total aerobic	9.7	8.2	9.1	8.8	6.9	7.7	9.9	8.7	9.6	9.0	8.1
Yeasts	8.1	5.7	6.1	4.1	3.5	4.5	8.3	6.1	6.6	4.3	4.9
Fungi	6.5	6.1	4.9	3.5	<2.0	5.0	6.6	6.6	5.7	3.7	5.5
Streptomycetes	2.5	6.8	6.5	7.4	4.0	7.2	2.7	7.4	6.9	7.6	7.6

[1]Description of 5,000-10,000 head cattle feedlot in Illinois in Microbiological Materials and Methods section. [2]Collection time of samples: 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971; 7, Sept 1971. Samples from associated sites collected at times indicated for waste samples in same column. [3]Associated site samples: Fd = feed from trough; Sp = stockpiled (old) FLW; FM = field (Mar)*; PD = pen dirt; FD = field ditch; FS = field (Sept)*. *FLW spread on field previous winter.

TABLE 17.--Distribution of aerobic populations in pristine (fresh) cattle waste (AP) and cattle waste (A) from Feedlot A

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]							
			Feedlot AP[3]				Feedlot A			
			1	2	3	4	1	2	3	4
Group 1 - G+ or Gv rods;			0	0	10	1	74	0	1	60
diphtheroids	nonmot	1	-	-	-	1	70	-	-	50
	nonmot	2	-	-	10	-	*2	-	1	-
	nonmot	6	-	-	-	-	1	-	-	10
	nonmot	38	-	-	-	-	1	-	-	-
Group 2 - G+/G- irregular			82	23	0	1	0	91	0	0
rods; ovoid, coccoid	nonmot	2	*81	10	-	1	-	*11	-	-
forms; granular	mot	2	-	10	-	-	-	-	-	-
	nonmot	3	-	1	-	-	-	**70	-	-
	nonmot	4	-	1	-	-	-	-	-	-
	nonmot	12	1	-	-	-	-	-	-	-
	nonmot	46	-	-	-	-	-	10	-	-
	nonmot	111	-	1	-	-	-	-	-	-
Group 3 - G- large rods;			2	0	0	0	0	0	0	0
single or palisade	mot	7	1	-	-	-	-	-	-	-
	mot	23	1	-	-	-	-	-	-	-
Group 5 - G+ small rods;			2	50	0	1	12	1	30	12
single	nonmot	2	1	40	-	-	-	-	30	-
	mot	2	-	10	-	-	-	-	-	-
	nonmot	5	-	-	-	-	-	-	-	1
	nonmot	9	-	-	-	-	10	-	-	-
	nonmot	10	-	-	-	-	1	-	-	-
	mot	22	1	-	-	-	-	-	-	-
	nonmot	44	-	-	-	-	-	-	-	1
	nonmot	50	-	-	-	1	-	-	-	-
	nonmot	70	-	-	-	-	-	1	-	-

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	nonmot	102	-	-	-	-	1	-	-	-
	nonmot	122	-	-	-	-	-	-	-	10
Group 6 - G+ small rods;			0	10	0	60	0	0	1	0
chains	nonmot	2	-	10	-	60	-	-	-	-
	mot	51	-	-	-	-	-	-	1	-
Group 7 - G- small rods;			0	0	30	1	0	0	50	0
single	nonmot	3	-	-	-	-	-	-	10	-
	mot	7	1	-	**30	-	-	-	-	-
	mot	25	-	-	-	-	-	-	*40	-
	nonmot	114	-	-	-	1	-	-	-	-
Group 9 - G+ cocci; clusters	nonmot	2	0	0	1	0	0	0	0	0
Group 10 - G+ cocci; tetrads or packets	nonmot	2	0	0	*21	0	0	0	0	0
Group 11 - G+ cocci; pairs	nonmot	8	1	0	0	0	0	0	0	0
Group 12 - G-/Gv cocci; pairs	nonmot	2	0	0	0	1	0	0	0	0
Group 13 - G+ cocci;			0	0	1	0	0	0	0	10
single	nonmot	4	-	-	-	-	-	-	-	10
	nonmot	70	-	-	1	-	-	-	-	-
Total			87	83	63	65	86	92	82	82

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percents: 10 percent = any value between 10 and 20 percent, 20 percent = any value between 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of samples: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 18.--Distribution of aerobic populations in cattle waste from Feedlots B and C

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]							
			Feedlot B[3]				Feedlot C			
			1	2	3	4	1	2	3	4
Group 1 - G+ or Gv rods; diphtheroids			21	1	30	21	0	70	3	2
	nonmot	1	20	1	20	20	-	70	*2	1
	nonmot	4	-	-	10	-	-	-	-	-
	nonmot	5	-	-	-	-	-	-	1	1
	nonmot	13	1	-	-	1	-	-	-	-
Group 2 - G+/G- irregular rods; ovoid, coccoid forms; granular			11	50	0	10	73	12	0	30
	nonmot	2	-	-	-	-	**32	1	-	-
	nonmot	5	-	-	-	-	-	10	-	-
	nonmot	6	-	-	-	-	-	1	-	-
	nonmot	8	-	-	-	-	-	-	-	30
	nonmot	11	-	-	-	10	-	-	-	-
	mot	12	1	-	-	-	-	-	-	-
	nonmot	17	10	40	-	-	-	-	-	-
	nonmot	39	-	-	-	-	*31	-	-	-
	nonmot	46	-	-	-	-	10	-	-	-
	nonmot	111	-	10	-	-	-	-	-	-
Group 4 - G+ large rods; single or chains	nonmot	36	0	0	0	0	0	1	0	0
Group 5 - G+ small rods; single			14	40	41	21	0	21	6	41
	nonmot	2	*2	-	-	-	-	-	-	-
	mot	2	1	-	-	-	-	-	-	-
	nonmot	3	-	-	-	10	-	-	-	-
	nonmot	4	10	*30	1	-	-	-	*2	-
	nonmot	5	-	-	-	-	-	-	-	*31
	nonmot	6	-	-	10	-	-	20	*2	-
	nonmot	16	1	-	-	-	-	-	-	-
	nonmot	17	-	-	10	-	-	-	-	-
	mot	31	-	-	-	-	-	-	1	-
	mot	33	-	-	-	-	-	-	1	-

	nonmot	38	-	-	-	-	-	-	-	10
	nonmot	47	-	-	-	1	-	-	-	-
	nonmot	59	-	10	-	-	-	-	-	-
	nonmot	103	-	-	-	10	-	-	-	-
	nonmot	104	-	-	20	-	-	-	-	-
	nonmot	119	-	-	-	-	-	1	-	-
Group 6 - G+ small rods; chains	mot	75	0	0	0	0	0	0	1	0
Group 7 - G- small rods;			12	1	1	11	0	0	0	0
single	nonmot	5	-	1	-	-	-	-	-	-
	nonmot	9	1	-	-	1	-	-	-	-
	mot	13	10	-	-	-	-	-	-	-
	nonmot	35	-	-	-	10	-	-	-	-
	nonmot	78	-	-	1	-	-	-	-	-
	nonmot	117	1	-	-	-	-	-	-	-
Group 10 - G+ cocci; tetrads or packets	nonmot	88	1	0	0	0	0	0	0	0
Group 13 - G+ cocci;			0	0	11	20	0	0	0	1
single	nonmot	4	-	-	-	20	-	-	-	-
	nonmot	5	-	-	1	-	-	-	-	-
	nonmot	13	-	-	10	-	-	-	-	-
	nonmot	45	-	-	-	-	-	-	-	1
Total			59	92	83	83	73	104	10	74

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percent: 10 percent = any value between 10 and 20 percent, 20 percent = any value between 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of samples: 1, Summer 1971; 3, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 19.--Distribution of aerobic populations in cattle waste from Feedlots D and E

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]							
			Feedlot D[3]				Feedlot E			
			1	2	3	4	1	2	3	4
Group 1 - G+ or Gv rods; diphtheroids			0	0	10	0	0	11	20	10
	nonmot	1	-	-	-	-	-	-	20	10
	nonmot	3	-	-	10	-	-	-	-	-
	nonmot	63	-	-	-	-	-	1	-	-
	nonmot	89	-	-	-	-	-	10	-	-
Group 2 - G+/G- irregular rods; ovoid, coccoid forms; granular			3	70	0	0	4	21	0	0
	nonmot	2	-	50	-	-	-	-	-	-
	nonmot	3	-	*20	-	-	-	-	-	-
	nonmot	4	-	-	-	-	*2	-	-	-
	nonmot	8	-	-	-	-	-	20	-	-
	nonmot	12	1	-	-	-	1	-	-	-
	nonmot	59	-	-	-	-	1	-	-	-
	nonmot	85	-	-	-	-	-	1	-	-
	mot	93	1	-	-	-	-	-	-	-
	nonmot	95	1	-	-	-	-	-	-	-
Group 4 - G+ large rods; single or chains (spores formed in 83)			1	1	0	0	0	0	1	0
	nonmot	15	-	-	-	-	-	-	1	-
	nonmot	45	1	-	-	-	-	-	-	-
	nonmot	83	-	1	-	-	-	-	-	-
Group 5 - G+ small rods; single			1	22	41	80	1	30	0	3
	nonmot	3	-	**21	20	-	-	20	-	-
	nonmot	5	1	-	-	-	-	-	-	-
	nonmot	14	-	-	-	-	-	-	-	1
	mot	20	-	-	-	80	-	-	-	-
	nonmot	55	-	1	-	-	-	-	-	-
	nonmot	64	-	-	1	-	-	-	-	-
	nonmot	103	-	-	-	-	-	-	-	*2

	nonmot	110	-	-	-	-	1	-	-	-
	nonmot	118	-	-	-	-	-	10	-	-
	nonmot	121	-	-	20	-	-	-	-	-
Group 7 - G- small rods;			70	0	2	1	43	11	31	20
single	nonmot	5	-	-	-	-	*31	-	-	-
	mot	7	-	-	1	-	-	-	*30	-
	nonmot	13	-	-	-	1	-	-	-	-
	mot	25	-	-	-	-	-	-	1	-
	mot	26	-	-	-	-	-	-	-	20
	mot	39	-	-	-	-	1	-	-	-
	nonmot	53	-	-	1	-	-	-	-	-
	nonmot	58	-	-	-	-	-	10	-	-
	nonmot	61	-	-	-	-	-	1	-	-
	nonmot	62	40	-	-	-	-	-	-	-
	mot	68	10	-	-	-	-	-	-	-
	nonmot	82	20	-	-	-	-	-	-	-
	nonmot	111	-	-	-	-	10	-	-	-
	nonmot	123	-	-	-	-	1	-	-	-
Group 8 - G+ cocci; chains	nonmot	2	0	0	0	0	0	0	10	0
Group 9 - G+ cocci; clusters	nonmot	4	0	0	0	0	0	0	1	0
Group 10 - G+ cocci;			0	0	0	0	0	0	11	20
tetrads or packets	nonmot	2	-	-	-	-	-	-	*11	10
	nonmot	3	-	-	-	-	-	-	-	10
Group 12 - G-/Gv cocci; pairs	nonmot	12	0	0	0	0	0	0	0	*20
Group 13 - G+ cocci; single	nonmot	44	0	0	10	0	0	0	0	0
Group 14 - Yeasts;			0	1	0	1	0	0	0	0
ellipsoidal	nonmot	29	-	1	-	-	-	-	-	-
	nonmot	118	-	-	-	1	-	-	-	-
Total			75	94	73	82	48	73	74	73

See footnotes at end of Table 18.

TABLE 20.--Distribution of aerobic populations in cattle waste from Feedlots G and H

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]							
			Feedlot G[3]				Feedlot H			
			1	2	3	4	1	2	3	4
Group 1 - G+ or Gv rods;			61	40	0	1	0	0	30	0
diphtheroids	nonmot	1	60	-	-	-	-	-	-	-
	nonmot	3	-	10	-	-	-	-	-	-
	nonmot	5	1	-	-	-	-	-	-	-
	nonmot	8	-	30	-	-	-	-	-	-
	nonmot	9	-	-	-	1	-	-	-	-
	nonmot	124	-	-	-	-	-	-	30	-
Group 2 - G+/G- irregular			2	0	1	0	11	0	0	0
rods; ovoid, coccoid	nonmot	2	-	-	1	-	-	-	-	-
forms; granular	nonmot	4	-	-	-	-	1	-	-	-
	nonmot	44	-	-	-	-	10	-	-	-
	nonmot	46	*2	-	-	-	-	-	-	-
Group 4 - G+ large rods;										
single or chains	nonmot	34	0	0	0	0	0	30	0	0
Group 5 - G+ small rods;			31	40	2	2	21	0	3	82
single	nonmot	3	-	-	-	1	-	-	-	-
	nonmot	4	1	-	-	-	-	-	-	-
	nonmot	5	-	-	-	-	20	-	1	-
	nonmot	8	-	40	-	-	-	-	-	-
	nonmot	9	30	-	-	1	-	-	-	-
	nonmot	28	-	-	-	-	-	-	1	-
	nonmot	32	-	-	-	-	1	-	-	-
	nonmot	56	-	-	-	-	-	-	-	*81
	nonmot	59	-	-	-	-	-	-	1	-
	mot	74	-	-	1	-	-	-	-	-
	nonmot	80	-	-	1	-	-	-	-	-
	nonmot	81	-	-	-	-	-	-	-	1

Group 6 - G+ small rods;			0	20	10	0	0	0	1	0
chains	mot	2	-	-	10	-	-	-	-	-
	nonmot	8	-	20	-	-	-	-	1	-
Group 7 - G- small rods;			3	0	20	0	20	10	30	2
single	nonmot	3	-	-	-	-	-	-	20	-
	nonmot	5	1	-	-	-	-	-	-	-
	mot	7	-	-	10	-	-	-	-	-
	nonmot	18	-	-	-	-	20	-	-	-
	nonmot	34	1	-	-	-	-	-	-	-
	mot	40	-	-	-	-	-	-	-	1
	mot	65	-	-	-	-	-	-	10	-
	nonmot	77	-	-	10	-	-	-	-	-
	nonmot	81	-	-	-	-	-	-	-	1
	nonmot	109	-	-	-	-	-	10	-	-
	nonmot	113	1	-	-	-	-	-	-	-
Group 8 - G+ cocci; chains			0	0	22	0	0	1	0	0
	nonmot	2	-	-	1	-	-	-	-	-
	mot	8	-	-	1	-	-	-	-	-
	nonmot	16	-	-	20	-	-	-	-	-
	mot	35	-	-	-	-	-	1	-	-
Group 13 - G+ cocci; single			0	0	0	1	0	0	1	0
	nonmot	5	-	-	-	-	-	-	1	-
	nonmot	44	-	-	-	1	-	-	-	-
Group 15 - Streptomycetes			0	0	0	0	0	60	0	0
	nonmot	97	-	-	-	-	-	10	-	-
	nonmot	106	-	-	-	-	-	50	-	-
Total			97	100	55	4	52	101	65	84

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percents: 10 percent = any value between 10 and 20 percent, 20 percent = any value between 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of samples: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 21.--Distribution of aerobic populations in hog waste from Feedlots F and I

Microscopic appearance		Biochemical type[1]	Percent of total aerobes in sample[2]							
			Feedlot F[3]				Feedlot I			
			1	2	3	4	1	2	3	4
Group 1 - G+ or Gv rods; diphtheroids				20	2		0	1	0	0
	nonmot	5		20	-		-	-	-	-
	nonmot	8		-	1		-	1	-	-
	nonmot	84		-	1		-	-	-	-
Group 2 - G+/G- irregular rods; ovoid, coccoid forms; granular	nonmot	49		30	0		0	0	0	0
Group 3 - G- large rods; single or palisade				10	0		30	0	0	0
	mot	21		10	-		-	-	-	-
	mot	30		-	-		10	-	-	-
	mot	37		-	-		*20	-	-	-
Group 4 - G+ large rods; single or chains				20	0		0	30	0	10
	nonmot	3		-	-		-	20	-	-
	nonmot	15		10	-		-	-	-	-
	nonmot	16		-	-		-	10	-	-
	nonmot	66		10	-		-	-	-	-
	nonmot	127		-	-		-	-	-	10
Group 5 - G+ small rods; single				0	0		0	51	21	3
	nonmot	3		-	-		-	-	10	-
	nonmot	5		-	-		-	-	-	*2
	nonmot	8		-	-		-	-	1	-
	nonmot	16		-	-		-	-	10	-
	nonmot	18		-	-		-	*50	-	-
	nonmot	76		-	-		-	1	-	-
	nonmot	120		-	-		-	-	-	1

no countable plates

no viable colonies on plates

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Group 6 - G+ small rods;			0	2	1	0	0	0
chains	nonmot	73	-	-	1	-	-	-
	nonmot	84	-	*2	-	-	-	-
Group 7 - G- small rods;			1	2	0	12	1	10
single	nonmot	2	-	1	-	-	-	-
	nonmot	5	-	1	-	10	-	-
	mot	7	-	-	-	1	-	-
	mot	15	-	-	-	-	-	10
	mot	23	-	-	-	1	-	-
	mot	24	1	-	-	-	-	-
	nonmot	99	-	-	-	-	1	-
Group 8 - G+ cocci; chains			10	1	0	0	0	0
	nonmot	15	10	-	-	-	-	-
	nonmot	48	-	1	-	-	-	-
Group 12 - G-/Gv cocci;			0	0	0	0	0	30
pairs	nonmot	2	-	-	-	-	-	*20
	nonmot	12	-	-	-	-	-	10
Group 13 - G+ cocci; single			0	1	0	0	0	10
	nonmot	4	-	1	-	-	-	-
	nonmot	5	-	-	-	-	-	10
Group 14 - Yeasts;			1	0	1	0	70	0
apiculate (8), or	nonmot	8	-	-	1	-	-	-
ellipsoidal (29 and 43)	nonmot	29	-	-	-	-	*70	-
	nonmot	43	1	-	-	-	-	-
Total			91	8	32	94	92	63

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percents: 10 percent = any value between 10 and 20 percent, 20 percent = any value vetween 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of samples: 1, Summer 1971; 2, Winter 1972; 3, Spring 1972; 4, Summer 1972.

TABLE 22.--Distribution of aerobic populations in cattle waste from Feedlot J

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2] 1[3]	2	3	4	5	6	7
Group 1 - G+ or Gv rods; diphtheroids			70	71	62	21	24	41	61
	nonmot	1	*60	*40	30	1	20	*41	60
	nonmot	3	-	20	-	-	-	-	-
	nonmot	5	-	-	-	-	1	-	-
	nonmot	6	-	-	-	-	-	-	1
	nonmot	10	-	-	1	-	-	-	-
	nonmot	11	-	10	30	-	1	-	-
	nonmot	14	10	-	-	-	-	-	-
	nonmot	52	-	1	-	-	-	-	-
	nonmot	67	-	-	1	-	-	-	-
	nonmot	86	-	-	-	-	1	-	-
	nonmot	105	-	-	-	-	1	-	-
	nonmot	126	-	-	-	20	-	-	-
Group 2 - G+/G- irregular rods; ovoid, coccoid forms; granular			10	0	0	2	4	1	0
	nonmot	4	-	-	-	-	1	-	-
	nonmot	6	10	-	-	-	1	-	-
	nonmot	11	-	-	-	1	1	1	-
	nonmot	118	-	-	-	1	-	-	-
	nonmot	123	-	-	-	-	1	-	-
Group 5 - G+ small rods; single			0	1	3	4	1	11	0
	nonmot	5	-	-	-	1	-	-	-
	nonmot	6	-	-	*2	1	-	-	-
	nonmot	9	-	-	-	-	-	10	-
	nonmot	14	-	1	-	-	-	-	-
	nonmot	41	-	-	1	-	-	-	-
	nonmot	42	-	-	-	-	1	-	-
	nonmot	80	-	-	-	1	-	1	-
	nonmot	94	-	-	-	1	-	-	-

Group 7 - G- small rods;			1	1	2	2	8	0	0
single	nonmot	2	-	-	-	-	1	-	-
	mot	3	-	-	-	-	1	-	-
	nonmot	4	-	1	1	-	-	-	-
	nonmot	5	1	-	-	-	1	-	-
	mot	7	-	-	1	-	-	-	-
	nonmot	9	-	-	-	-	1	-	-
	nonmot	10	-	-	-	1	1	-	-
	nonmot	61	-	-	-	1	-	-	-
	nonmot	87	-	-	-	-	1	-	-
	nonmot	92	-	-	-	-	1	-	-
	nonmot	109	-	-	-	-	1	-	-
Group 8 - G+ cocci; chains	nonmot	4	0	0	*2	0	0	0	0
Group 9 - G+ cocci; clusters	nonmot	4	1	0	0	0	0	0	0
Group 10 - G+ cocci; tetrads or packets	nonmot	4	0	0	0	30	0	0	0
Group 12 - G-/Gv cocci;			0	0	0	1	0	20	0
pairs	nonmot	117	-	-	-	-	-	20	-
	nonmot	118	-	-	-	1	-	-	-
Group 13 - G+ cocci; single	nonmot	5	0	1	0	0	0	0	0
Total			82	74	69	60	37	73	61

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percents: 10 percent = any value between 10 and 20 percent, 20 percent = any value between 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of samples; 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971; 7, Sept 1971.

TABLE 23.--Distribution of aerobic populations in runoff from cattle pens on Feedlot J

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]						
			1[3]	2	3	4	5	6	7
Group 1 - G+ or Gv rods;			60	52	30	2	62	11	21
diphtheroids	nonmot	1	30	30	20	1	1	*11	20
	nonmot	5	-	1	-	-	-	-	-
	nonmot	6	10	-	10	-	-	-	1
	nonmot	10	-	-	-	-	60	-	-
	nonmot	11	-	-	-	-	1	-	-
	nonmot	14	20	-	-	-	-	-	-
	nonmot	59	-	-	-	1	-	-	-
	nonmot	61	-	20	-	-	-	-	-
	nonmot	100	-	1	-	-	-	-	-
Group 2 - G+/G- irregular			0	1	0	0	1	10	0
rods; ovoid, coccoid	nonmot	4	-	1	-	-	-	-	-
forms; granular	nonmot	6	-	-	-	-	-	10	-
	nonmot	112	-	-	-	-	1	-	-
Group 5 - G+ small rods;			0	10	1	3	0	21	1
single or chains	nonmot	4	-	-	-	-	-	-	1
	nonmot	6	-	-	1	1	-	-	-
	nonmot	10	-	10	-	-	-	-	-
	nonmot	45	-	-	-	-	-	20	-
	nonmot	86	-	-	-	1	-	-	-
	nonmot	98	-	-	-	1	-	-	-
	nonmot	122	-	-	-	-	-	1	-
Group 7 - G- small rods;			2	1	12	5	22	31	1
single	nonmot	5	-	-	1	1	1	10	-
	mot	7	1	-	-	-	-	-	-
	nonmot	9	-	-	-	-	-	-	1
	nonmot	10	-	-	-	1	-	-	-
	nonmot	13	-	-	-	-	-	20	-

	nonmot	61	-	-	-	-	1	-	-
	nonmot	84	-	-	10	1	-	-	-
	nonmot	107	-	-	-	1	-	-	-
	nonmot	114	-	-	-	-	-	1	-
	nonmot	123	-	1	-	1	-	-	-
	nonmot	125	-	-	1	-	-	-	-
	nonmot	127	1	-	-	-	20	-	-
Group 8 - G+ cocci; chains			10	0	1	11	0	0	0
	nonmot	2	-	-	-	10	-	-	-
	mot	12	-	-	1	-	-	-	-
	nonmot	60	-	-	-	1	-	-	-
	nonmot	69	10	-	-	-	-	-	-
Group 10 - G+ cocci; tetrads or packets	nonmot	93	0	0	0	0	0	20	0
Group 11 - G+ cocci; pairs	nonmot	71	0	0	0	1	0	0	0
Group 12 - G-/Gv cocci;			0	0	3	40	0	0	0
pairs	nonmot	4	-	-	*2	40	-	-	-
	nonmot	5	-	-	1	-	-	-	-
Group 13 - G+ cocci;			0	10	1	0	0	0	0
single	nonmot	9	-	10	-	-	-	-	-
	nonmot	119	-	-	1	-	-	-	-
Total			72	74	48	62	85	93	23

[1]Biochemical types: biochemical capabilities of isolates listed by number in Table 25. [2]Percent of total aerobes: various colony types picked from countable plates; percent of total estimated for each colony type and recorded by 10 percents: 10 percent = any value between 10 and 20 percent, 20 percent = any value between 20 and 30 percent, etc.; 1 percent = any value less than 10 percent. Note: two (*) or three (**) different colony types with the same microscopic appearance and biochemical capabilities contribute to the value given. [3]Collection time of Runoff samples: 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971; 7, Sept 1971. Associated site samples: feed, Nov 1970; stockpile, Jan 1971; field (Mar), Mar 1971 - FLW spread on field previous winter; pen dirt, May 1971; field ditch, July 1971; field (Sept), Sept 1971 - same field as Mar sample.

TABLE 24.--Distribution of aerobic populations from sites associated with cattle waste on Feedlot J

Microscopic appearance	Motility	Biochemical type[1]	Percent of total aerobes in sample[2]					
			Feed[3]	Stock-pile	Field, Mar	Pen dirt	Field ditch	Field, Sept
Group 1 - G+ or Gv rods;			1	0	5	52	20	0
diphtheroids	nonmot	1	-	-	1	50	20	-
	nonmot	6	-	-	1	-	-	-
	nonmot	8	1	-	-	-	-	-
	nonmot	10	-	-	1	1	-	-
	nonmot	11	-	-	-	1	-	-
	nonmot	86	-	-	1	-	-	-
	nonmot	93	-	-	1	-	-	-
Group 2 - G+/G- irregular			0	0	3	3	0	0
rods; ovoid, coccoid	nonmot	6	-	-	*2	1	-	-
forms; granular	nonmot	11	-	-	-	1	-	-
	nonmot	97	-	-	1	-	-	-
	nonmot	107	-	-	-	1	-	-
Group 5 - G+ small rods;			1	0	0	1	21	1
single	nonmot	4	-	-	-	-	1	-
	nonmot	14	-	-	-	-	20	-
	mot	49	-	-	-	1	-	-
	nonmot	99	-	-	-	-	-	1
	nonmot	119	1	-	-	-	-	-
Group 7 - G- small rods;			14	20	11	2	1	42
single	nonmot	2	-	-	-	-	-	20
	nonmot	3	-	-	-	-	-	10
	nonmot	4	-	*2	-	-	-	-
	nonmot	5	-	*2	-	1	-	1
	nonmot	10	*2	1	-	-	-	10
	nonmot	13	-	-	-	-	1	-
	nonmot	27	1	-	-	-	-	-
	nonmot	72	-	-	1	-	-	-

	nonmot	79	-	1	-	-	-	-
	nonmot	84	-	-	10	-	-	-
	nonmot	90	1	-	-	-	-	-
	nonmot	91	-	10	-	-	-	-
	nonmot	100	-	1	-	-	-	-
	nonmot	101	-	1	-	-	-	-
	nonmot	108	-	1	-	-	-	-
	mot	116	-	-	-	-	-	1
	nonmot	123	10	-	-	-	-	-
	nonmot	127	-	1	-	1	-	-
Group 8 - G+ cocci; chains	nonmot	5	0	1	0	0	0	0
Group 10 - G+ cocci; tetrads or packets	nonmot	38	0	0	1	0	0	0
Group 11 - G+ cocci; pairs	nonmot	86	0	0	1	0	0	0
Group 12 - G-/Gv cocci;			0	1	11	0	0	0
pairs	nonmot	4	-	-	*11	-	-	-
	nonmot	5	-	1	-	-	-	-
Group 13 - G+ cocci; single	nonmot	4	*31	0	0	0	0	0
Group 14 - Yeasts;			2	0	0	0	0	1
ellipsoidal	nonmot	6	1	-	-	-	-	-
	nonmot	8	1	-	-	-	-	-
	nonmot	115	-	-	-	-	-	1
Group 15 - Streptomycetes			0	0	2	1	0	30
	nonmot	54	-	-	-	-	-	20
	nonmot	57	-	-	-	1	-	-
	nonmot	96	-	-	-	-	-	10
	nonmot	128	-	-	*2	-	-	-
Total			49	22	34	59	42	74

See footnotes at end of Table 23.

TABLE 25.--Biochemical capabilities of aerobes isolated from all feedlots (biochemical type list)

Biochemical type[1]	Biochemical capabilities[2]											Number of[3] isolates		
	Zein	Starch	Cellulose	Lipid	Glucose	Xylose	Lactose	Litmus milk	Nitrate red.	Urea	H_2S	Indol	>10 percent	<10 percent	Total
1[4]	-	-	-	-	V	-	-	U	v	v	-	-	24	11	35
2	-	-	-	-	A	A	A	U	-	-	-	-	21	21	42
3	-	-	-	-	A	A	-	U	-	-	-	-	19	4	23
4	-	-	-	-	-	-	-	U	+	-	-	-	10	25	35
5	-	-	-	-	-	-	-	U	-	-	-	-	8	31	39
6	-	-	-	-	A	-	-	U	+	-	-	-	7	17	24
7	-	-	-	-	AG	A	A	A	+	-	-	+	6	5	11
8	-	-	-	-	A	-	-	U	-	-	-	-	5	9	14
9	+	-	-	-	-	-	-	U	-	-	-	-	4	6	10
10	-	+	-	-	-	-	-	U	-	-	-	-	3	10	13
11	-	+	-	-	A	-	-	U	+	-	-	-	3	7	10
12	-	-	-	-	A	A	A	A	-	-	-	-	3	5	8
13	-	-	-	-	A	A	A	A	+	-	-	-	3	4	7
14	+	-	-	-	-	-	-	P	-	-	-	-	3	2	5
15	-	-	-	-	A	A	A	U	-	-	+	-	3	1	4
16	-	-	-	-	A	-	A	U	-	-	-	-	3	1	4
17	-	-	-	+	A	-	-	U	+	-	-	-	3	0	3
18[5]	-	-	-	-	A	-	-	A	-	-	-	-	3	0	3
20	+	+	-	-	AG	A	A	ACR	+	-	-	+	1	0	1
21	+	-	-	-	AG	A	A	U	+	+	+	+	1	0	1
22	+	-	-	-	AG	A	A	AR	+	-	-	+	0	1	1

Biochemical type	Biochemical capabilities											Number of isolates		
	Zein	Starch	Cellulose	Lipid	Glucose	Xylose	Lactose	Litmus milk	Nitrate red.	Urea	H_2S	Indol	>10 percent	<10 percent	Total
55	+	-	-	-	A	A	-	U	-	-	-	-	0	1	1
56	+	-	-	-	A	A	-	KPR	-	-	-	-	1	1	2
57	-	+	-	+	A	A	-	U	+	-	-	-	0	1	1
58	-	+	-	+	A	A	-	U	-	-	-	-	1	0	1
59	-	+	-	-	A	A	-	U	+	-	-	-	1	3	4
60	-	+	-	-	A	A	-	K	+	-	-	-	0	1	1
61	-	+	-	-	A	A	-	U	-	-	-	-	1	3	4
62	-	-	-	+	A	A	-	R	+	-	-	-	1	0	1
63	-	-	-	+	A	A	-	R	-	-	-	-	0	1	1
64	-	-	-	+	A	A	-	K	-	-	-	-	0	1	1
65	-	-	-	-	A	A	-	AR	+	-	-	+	1	0	1
66	-	-	-	-	A	A	-	U	-	-	+	-	1	0	1
67	-	-	-	-	A	A	-	R	-	-	-	-	0	1	1
68	-	+	-	+	A	-	A	R	-	-	-	-	1	0	1
69	-	+	-	-	A	-	A	AR	-	-	-	-	1	0	1
70	-	-	-	+	A	-	A	ACR	+	+	-	-	0	2	2
71	-	-	-	-	A	-	A	AC	+	+	-	-	0	1	1
72	-	-	-	-	A	-	A	P	-	+	-	-	0	1	1
73	-	-	-	-	A	-	A	A	-	-	-	-	0	1	1
74	+	+	-	+	A	-	-	ACR	+	-	-	-	0	1	1
75	+	+	-	+	A	-	-	KPR	+	-	-	-	0	1	1
76	+	+	-	-	A	-	-	R	+	-	-	-	0	1	1
77	+	-	-	+	A	-	-	U	-	-	-	-	1	0	1

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23	-	+	-	-	AG	A	A	A	+	-	-	+	0	2	2	78	+	-	-	+	A	-	-	KPR	-	-	-	-	0	1	1
24	-	-	-	-	AG	A	A	U	+	+	+	+	0	1	1	79	+	-	-	-	A	-	-	U	+	-	-	-	0	1	1
25	-	-	-	-	AG	A	A	AR	+	-	-	+	2	1	3	80	+	-	-	-	A	-	-	U	-	-	-	-	0	3	3
26	-	-	-	-	AG	A	A	ACR	+	-	-	+	1	0	1	81	+	-	-	-	A	-	-	KPR	-	-	-	-	0	2	2
27	-	-	-	-	AG	A	A	A	+	-	-	-	0	1	1	82	-	+	-	+	A	-	-	K	-	+	-	-	1	0	1
28	-	-	-	-	AG	A	A	U	-	-	-	-	0	1	1	83	-	+	-	+	A	-	-	U	-	-	-	-	0	1	1
29	-	-	-	-	AG	A	-	U	-	-	-	-	2	1	3	84	-	+	-	-	A	-	-	U	-	-	-	-	2	4	6
30	-	+	-	-	AG	-	A	A	+	-	-	+	1	0	1	85	-	-	-	+	A	-	-	U	-	-	-	-	0	1	1
31	+	+	-	+	A	A	A	ACR	+	-	-	-	0	1	1	86	-	-	-	-	A	-	-	K	+	+	-	-	0	4	4
32	+	+	-	+	A	A	A	KPR	+	-	-	-	0	1	1	87	-	-	-	-	A	-	-	R	+	-	-	-	0	1	1
33	+	+	-	-	A	A	A	KPR	+	+	-	-	0	1	1	88	-	-	-	-	A	-	-	U	-	+	-	-	0	1	1
34	+	+	-	-	A	A	A	U	+	-	-	-	1	1	2	89	+	-	-	-	-	A	-	U	-	-	-	-	1	0	1
35	+	+	-	-	A	A	A	AR	+	-	-	-	1	1	2	90	-	+	-	-	-	A	-	U	-	-	-	-	0	1	1
36	+	+	-	-	A	A	A	ACPR	+	-	-	-	0	1	1	91	+	+	-	-	-	-	-	U	+	-	-	-	1	0	1
37	-	+	-	-	A	A	A	A	+	-	-	+	2	0	2	92	+	+	-	-	-	-	-	K	+	-	-	-	0	1	1
38	-	+	-	-	A	A	A	U	+	-	-	-	1	2	3	93	+	+	-	-	-	-	-	U	-	-	-	-	1	2	3
39	-	+	-	-	A	A	A	U	-	-	-	-	1	2	3	94	+	+	-	-	-	-	-	K	-	-	-	-	0	1	1
40	-	+	-	-	A	A	A	AR	-	-	-	-	0	1	1	95	+	-	-	+	-	-	-	U	+	+	-	-	0	1	1
41	-	+	-	-	A	A	A	ACR	-	-	-	-	0	1	1	96	+	-	-	+	-	-	-	P	-	-	-	-	1	0	1
42	-	-	-	+	A	A	A	U	-	-	-	-	0	1	1	97	+	-	-	-	-	-	-	U	+	+	-	-	1	1	2
43	-	-	-	+	A	A	A	P	-	-	-	-	0	1	1	98	+	-	-	-	-	-	-	K	+	+	-	-	0	1	1
44	-	-	-	-	A	A	A	U	+	+	-	-	2	2	4	99	+	-	-	-	-	-	-	U	+	-	-	-	0	2	2
45	-	-	-	-	A	A	A	U	+	-	-	-	1	2	3	100	+	-	-	-	-	-	-	U	-	+	-	-	0	2	2
46	-	-	-	-	A	A	A	U	-	+	-	-	2	2	4	101	+	-	-	-	-	-	-	K	-	-	-	-	0	1	1
47	-	-	-	-	A	A	A	PR	-	+	-	-	0	1	1	102	+	-	-	-	-	-	-	KR	-	-	-	-	0	1	1
48	-	-	-	-	A	A	A	A	-	-	+	-	0	1	1	103	+	-	-	-	-	-	-	KP	-	-	-	-	1	2	3
49	-	-	-	-	A	A	A	AR	-	-	-	-	1	1	2	104	+	-	-	-	-	-	-	KPR	-	-	-	-	1	0	1
50	-	-	-	-	A	A	A	ACR	-	-	-	-	0	1	1	105	-	+	-	+	-	-	-	U	+	-	-	-	0	1	1
51	+	+	-	+	A	A	-	KPR	+	+	-	-	0	1	1	106	-	+	-	-	-	-	-	KP	+	+	-	-	1	0	1
52	+	+	-	-	A	A	-	K	-	-	-	-	0	1	1	107	-	+	-	-	-	-	-	U	+	-	-	-	0	2	2
53	+	-	-	+	A	A	-	U	-	-	-	-	0	1	1	108	-	+	-	-	-	-	-	K	-	+	-	-	0	1	1
54	+	-	-	-	A	A	-	P	+	-	-	-	1	0	1	109	-	+	-	-	-	-	-	K	-	-	-	-	1	1	2

See footnotes at end of table

TABLE 25.--Biochemical capabilities of aerobes isolated from all feedlots (biochemical type list)--continued

Biochemical type[1]	Biochemical capabilities[2]											Number of[3] isolates		
	Zein	Starch	Cellulose	Lipid	Glucose	Xylose	Lactose	Litmus milk	Nitrate red.	Urea	H_2S	Indol	>10 percent	<10 percent	Total
110	-	-	-	+	-	-	-	U	+	+	-	-	0	1	1
111	-	-	-	+	-	-	-	U	+	-	-	-	2	1	3
112	-	-	-	+	-	-	-	K	+	-	-	-	0	1	1
113	-	-	-	+	-	-	-	U	-	+	-	-	0	1	1
114	-	-	-	+	-	-	-	K	-	+	-	-	0	2	2
115	-	-	-	+	-	-	-	P	-	+	-	-	0	1	1
116	-	-	-	+	-	-	-	KP	-	+	-	-	0	1	1
117	-	-	-	+	-	-	-	U	-	-	-	-	1	1	2
118	-	-	-	-	-	-	-	U	+	+	-	-	1	3	4
119	-	-	-	-	-	-	-	K	+	+	-	-	0	3	3
120	-	-	-	-	-	-	-	KPR	-	-	-	-	0	1	1
121	-	-	-	-	-	-	-	R	+	-	-	-	1	0	1
122	-	-	-	-	-	-	-	K	+	-	-	-	1	1	2
123	-	-	-	-	-	-	-	U	-	+	-	-	1	4	5
124	-	-	-	-	-	-	-	K	-	+	-	-	1	0	1
125	-	-	-	-	-	-	-	U	-	-	-	+	0	1	1
126	-	-	-	-	-	-	-	R	-	-	-	+	1	0	1
127	-	-	-	-	-	-	-	K	-	-	-	-	2	3	5
128	-	-	-	-									0	2	2

[1]Biochemical type: reference number for biochemical capabilities of isolates in Tables 17 to 24, regardless of microscopic group. [2]Biochemical capabilities: Degradations: + = positive test, - = negative test; zein = zein hydrolysis; starch = starch hydrolysis; cellulose = cellulose degradation; lipid = hydrolysis of corn oil (Isolates from the following samples from Feedlot J were not tested on corn oil and are listed as negative: FLW and runoff samples 1, 2, 3 and 4 samples from feed, stockpile and field in Mar). Fermentation of glucose, xylose and lactose: AG = acid + gas produced (gas vials in glucose only), A = acid produced, - = no acid produced. Litmus milk reactions: U = unchanged, A = acid, C = coagulation, K = alkaline, P = proteolysis, R = litmus reduction. Other tests: + = positive test, - = negative test; nitrate red. = nitrite from nitrate; urea = urease produced; H_2S = H_2S produced; indol = indol produced. [3]Number of isolates: >10 percent or <10 percent = estimated percent of total like-appearing colonies on countable plates for sample. [4]Biochemical type 1 represents only one Corynbacterium sp.; variable reactions (v) listed for 52 isolates studied are - glucose: 41 A, 11 -; nitrate red.: 39 +, 13 -; urea: 5 +, 47 -. [5]First 18 biochemical types represent 71 percent of isolates >10 percent and 62 percent of total isolates.

TABLE 26.--Profile of microscopic groups of aerobic organisms in all samples

Microscopic group[1]	Swine waste		Pristine FLW	Feedlot waste (cattle)								Runoff	Associated sites (J)					
	F[2]	I	AP	A	B	C	D	E	G	H	J	J	Feed	Stockpile	Field, Mar	Pen dirt	Ditch	Field, Sept
	23	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234567	1234567						
1. G+/Gv rod; diphtheroid	X+	-+--	--X+	0-+0	0+00	-0++	--X-	-XXX	00-+	--0-	000X000	000+0X0	+	-	+	0	0	-
2. Gv irregular rod; granular	0-	----	0X-+	-0--	X0-X	0X-0	+0--	+X--	+-+-	X---	X--+++-	-+--+X-	-	-	+	+	-	-
3. G- large rod	X-	0---	+---	----	----	----	----	----	----	----	-------	-------	-	-	-	-	-	-
4. G+ large rod; single or chain	X-	-X-X	----	----	----	-+--	++--	--+-	----	-X--	-------	-------	-	-	-	-	-	-
5. G+ small rod; single	--	-0X-	+0-+	X+XX	XX0X	-X+X	+X00	+0-+	X0++	0-+0	-+++++-	-X++-X+	+	-	-	+	X	+
6. G+ small rod; chains	-+	+--+	-X-0	----	----	----	----	----	-XX-	--+-	-------	-------	-	-	-	-	-	-
7. G- small rod; single	++	-X+X	--0+	--0-	X++X	----	0-++	0X00	+-X-	XXX+	+++++--	++X+X0+	X	0	0	+	+	0
8. G+ coccus; chains	X+	----	----	----	----	----	----	--X-	--0-	-+--	--+----	X-+X---	-	+	-	-	-	-
9. G+ coccus; clusters	--	----	--+-	----	----	----	----	--+-	----	----	+------	-------	-	-	-	-	-	-
10. G+ coccus; tetrad, packet	--	----	--X-	----	+---	----	----	--XX	----	----	---0---	-----X-	-	-	+	-	-	-
11. G+ coccus; pairs	--	----	+---	----	----	----	----	----	----	----	-------	---+---	-	-	+	-	-	-
12. G-/Gv coccus; pairs	--	---0	---+	----	----	----	----	---X	----	----	---+-X-	--+0---	-	+	X	-	-	-
13. G+ coccus; single	-+	---X	--+-	---X	--XX	---+	--X-	----	---+	--+-	-+-----	-X-----	0	-	-	-	-	-
14. yeast	+-	+-0-	----	----	----	----	-+-+	----	----	----	-------	-------	+	-	-	-	-	+
15. streptomycete	--	----	----	----	----	----	----	----	----	-0--	-------	-------	-	-	+	+	-	0

[1]Designations of microscopic groups and numbers are those used in Tables 17-24; some descriptions are abbreviated. [2]Designations of feedlots and samples are those used in Tables 17-24; symbols used in table: 0 = predominant microscopic group in sample; X = more than 10 percent of sample population in this group; + = less than 10 percent of sample population in this group; - = no members of group isolated.

TABLE 27.--Profile of degradative capabilities of aerobic isolates from all feedlots

Distribution of isolates by microscopic group[1]															Degrades					No. of isolates	Distribution of isolates by source									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Zein	Starch	Cellulose	Lipid	Urea		Hog waste	Pristine FLW	FLW	Runoff	Feed	Stockpile	Field, Mar	Pen dirt	Field ditch	Field, Sept
-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	+	+	-	+	+	1	-	-	1	-	-	-	-	-	-	-
-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	+	+	-	+	-	4	1	-	3	-	-	-	-	-	-	-
-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	1	-	-	1	-	-	-	-	-	-	-
-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	1	-	-	1	-	-	-	-	-	-	-
-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	+	-	+	+	1	-	-	1	-	-	-	-	-	-	-
2	1	-	2	3	-	4	1	-	1	-	-	-	-	-	+	+	-	-	-	14	1	-	10	1	-	1	1	-	-	-
-	-	-	-	-	-	3	-	-	-	-	-	-	-	1	+	-	-	+	-	4	-	-	3	-	-	-	-	-	-	1
1	1	1	-	1	-	1	-	-	-	-	-	-	-	1	+	-	-	-	+	6	-	-	2	2	-	1	1	-	-	-
1	-	-	1	-	-	2	-	-	-	-	-	-	-	1	-	+	-	+	-	5	-	-	4	-	-	-	-	1	-	-
-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	+	-	-	+	2	-	-	1	-	-	1	-	-	-	-
-	-	-	-	2	-	4	-	-	-	-	-	1	1	-	-	-	-	+	+	8	-	2	3	1	-	-	-	-	-	2
4	-	-	-	21	-	8	-	-	-	-	-	1	-	1	+	-	-	-	-	35	1	1	25	3	-	2	-	-	1	2
13	9	4	-	6	2	20	2	-	1	-	-	-	-	-	-	+	-	-	-	57	7	1	24	13	3	1	3	4	-	1
1	6	-	-	3	-	3	-	-	-	-	1	-	1	-	-	-	-	+	-	15	-	1	13	1	-	-	-	-	-	-
3	7	-	-	6	-	6	-	-	1	2	1	3	1	-	-	-	-	-	+	30	1	-	19	5	2	-	3	-	-	-
64	40	1	7	56	6	55	11	3	7	1	13	11	6	2	-	-	-	-	-	283	34	26	158	33	6	7	8	5	3	3
89	65	6	10	102	10	108	14	3	10	3	15	16	9	7	Total					467	45	31	269	59	11	13	16	10	4	9

[1] Designation of microscopic groups are those used in Tables 17-24 and summarized in Table 26.

TABLE 28.--Biochemical capabilities and distribution of streptomycetes in feedlot waste, runoff, and associated site samples from cattle Feedlot J

Biochemical capabilities[1]				Number of isolates in sample																	
				Feedlot waste[2]						Runoff[2]						Associated site[3]					
Zein	St	Cell	Lip	1	2	3	4	5	6	1	2	3	4	5	6	Fd	Sp	FM	PD	FD	FS
+	+	-		5	2	8	2	-	-	4	10	3	3	-	-	1	19	7	-	-	-
+	+	-	+	-	-	-	-	6	4	-	-	-	-	3	3	-	-	-	9	1	1
+	+	-	-	-	-	-	-	4	0	-	-	-	-	1	4	-	-	-	5	1	2
+	-	-		0	0	0	0	-	-	0	0	0	0	-	-	0	1	1	-	-	-
+	-	-	+	-	-	-	-	2	0	-	-	-	-	3	0	-	-	-	0	0	0
+	-	-	-	-	-	-	-	2	0	-	-	-	-	1	0	-	-	-	2	0	0
-	+	-		1	3	1	16	-	-	0	8	7	5	-	-	0	4	6	-	-	-
-	+	-	+	-	-	-	-	3	1	-	-	-	-	2	2	-	-	-	8	0	6
-	+	-	-	-	-	-	-	2	1	-	-	-	-	2	2	-	-	-	6	2	8
-	-	-		0	0	0	1	-	-	0	4	3	4	-	-	0	1	21	-	-	-
-	-	-	+	-	-	-	-	2	0	-	-	-	-	0	0	-	-	-	0	0	3
-	-	-	-	-	-	-	-	0	0	-	-	-	-	1	0	-	-	-	6	0	2
Total No. in sample				6	5	9	19	21	6	4	22	13	12	13	11	1	25	35	36	4	22

[1]Zein = zein hydrolysis; st = starch hydrolysis; cell = cellulose degradation; lip = lipid (corn oil) hydrolysis. [2]FLW and runoff samples collected: 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971. [3]Associated site samples: Fd = feed; Sp = stockpiled (old) FLW; FM = field (Mar)*; PD = pen dirt; FD = field ditch; FS = field (Sept)*. *FLW spread on field previous winter.

TABLE 29.--Biochemical capabilities and distribution of non-filamentous yeasts in feedlot waste, runoff, and associated site samples from cattle Feedlot J

Biochemical capabilities[1]												Microscopic appearance[2]	Percent of total yeasts plus fungi in samples[3]																	
													Feedlot waste[4]						Runoff						Associated site					
Zein	Starch	Cellulose	Lipid	Glucose	Xylose	Lactose	Litmus milk	Nitrate red.	Urea	H_2S	Indol		1	2	3	4	5	6	1	2	3	4	5	6	Feed	Stockpile	Field, Mar[5]	Pen dirt	Ditch	Field, Sept
-	+	-		A	A	A	U	+	+	-	-	Ellipsoidal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	+	-		A	A	A	A	+	-	-	-	Ellipsoidal	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
-	+	-		A	A	-	U	-	-	-	-	Ellipsoidal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	+	-		A	a	-	U	-	+	-	-	Elp,term.budding	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	+	-		A	-	-	U	-	-	-	-	Ellipsoidal	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-		AG	A	-	U	-	-	-	-	Ellipsoidal	-	10	-	-	-	-	-	-	-	-	1	-	-	-	90	-	-	-
-	-	-	-	AG	-	-	U	-	-	-	-	Elongate	-	-	-	-	90	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-		AG	-	-	U	-	-	-	-	Ellipsoidal	-	40	50	-	-	-	-	-	6 30	-	-	-	-	-	1	-	-	-
-	-	-		AG	-	-	U	-	-	-	-	Elongate	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
-	-	-		AG	-	-	U	+	-	-	-	Ellipsoidal	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	±	A	A	A	U	-	+	-	-	Ellipsoidal	-	-	-	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	A	R	-	+	-	-	Ellipsoidal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
-	-	-		A	A	A	R	-	±	-	-	Elp + filamentous	10	10	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	A	P	-	±	-	-	Elp + filamentous	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	A	P	-	-	-	-	Elp + filamentous	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	A	KR	-	-	-	-	Elp,term.budding	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	-	U	+	-	-	-	Ellipsoidal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	-	U	-	-	-	-	Ellipsoidal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
-	-	-	-	A	A	-	U	-	-	-	-	Ellipsoidal	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
-	-	-	-	A	A	-	U	-	+	-	-	Elp,term.budding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	+	A	A	-	ACR	-	+	-	-	Elp + filamentous	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
-	-	-		A	A	-	U	-	±	-	-	Elp + filamentous	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	-	C	-	-	-	-	Filamentous	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
-	-	-		A	A	-	U	±	-	-	-	Apiculate	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-	-	A	-	-	U	-	-	-	-	Apiculate	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	10	-	-
-	-	-	-	-	-	-	U	±	-	-	-	Apiculate	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-

| | | |

TABLE 30.--Biochemical capabilities and distribution of fungi and filamentous yeasts in feedlot waste, runoff, and associated site samples from Feedlot J

Fungus or filamentous yeast	Biochemical capabilities[1]				Total No. of isolates in		Number of isolates in sample																	
							Feedlot waste[2]						Runoff						Associated site					
	Zein	Starch	Cellulose	Lipid	Genus or group	"Biotype"	1	2	3	4	5	6	1	2	3	4	5	6	Feed	Stockpile	Field, Mar[3]	Pen dirt	Field ditch	Field, Sept
Absidia corymbifera	-	+	-	ND	7	7	1	-	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Absidia spp.	-	+	-	+	16	10	-	-	-	-	1	4	-	-	-	-	1	-	-	-	-	4	-	-
	-	+	-	ND		6	-	2	-	-	-	-	-	1	-	1	-	-	2	-	-	-	-	-
Alternarnia	-	+	-	ND	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	-	-	-	ND		5	2	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	ND	ND	ND	ND		4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Aspergillus candidus	-	-	-	ND	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspergillus flavus	+	+	-	ND	5	4	-	-	-	1	-	-	-	-	-	-	-	-	3	-	-	-	-	-
	-	+	-	ND		1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspergillus fumigatus	+	-	-	ND	13	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	-	+	-	ND		10	2	2	1	2	-	-	1	-	1	-	-	-	1	-	-	-	-	-
	-	-	-	ND		2	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Aspergillus niger	+	+	-	ND	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	+	-	ND		1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	ND		1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Aspergillus terreus or ochraceus	-	+	-	+	11	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
	-	+	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	-	+	-	ND		6	2	-	-	1	-	-	1	-	2	-	-	-	-	-	-	-	-	-
	-	-	-	ND		1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

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Aspergillus spp.	+	+	-	ND	10	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	+	-	-		2	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
	ND	ND	ND	ND		7	-	-	-	-	-	6	-	-	-	-	-	1	-	-	-	-	-	-
Cephalosporium	-	-	-	ND	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Cladosporium	-	-	-	-	4	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	-	-	-	ND		3	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-
Dematiaceae	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Epicoccum nigrum	-	-	-	-	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Fusarium	+	+	-	-	18	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	-	+	-	+		1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	-	+	-	-		2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	-	+	-	ND		6	1	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	-	-
	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	-	-	-	ND		4	-	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
	ND	ND	ND	ND		3	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1
Geotrichum	-	-	-	+	17	3	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1
	-	-	-	ND		14	1	4	1	-	-	-	1	2	-	-	-	-	5	-	-	-	-	-
Graphium	+	+	-	ND	6	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	-	-	ND		2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	-	-	-	+		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	-	-	-	ND		1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Isaria	-	+	-	ND	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	-	-	-	ND		1	-	-	-	-	-	-	-	-	-	-	-	-	-	[4]1	-	-	-	-
Monascus	-	-	-	ND	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mucor caninus	-	-	-	ND	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mucor pusillus	-	+	-	ND	2	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-

See footnotes at end of table

TABLE 30.--Biochemical capabilities and distribution of fungi and filamentous yeasts in feedlot waste, runoff, and associated site samples from Feedlot J--continued

Fungus or filamentous yeast	Biochemical capabilities[1]				Total No. of isolates in		Number of isolates in sample																	
							Feedlot waste[2]						Runoff						Associated site					
	Zein	Starch	Cellulose	Lipid	Genus or group	"Bio-type"	1	2	3	4	5	6	1	2	3	4	5	6	Feed	Stockpile	Field, Mar[3]	Pen dirt	Field ditch	Field, Sept
Mucor spp.	-	+	-	+	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	-	+	-	ND		1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	-	-	-	ND		6	-	-	-	-	-	-	-	3	1	-	-	-	2	-	-	-	-	-
	ND	ND	ND	ND		1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Paecilomyces	-	+	-	ND	5	4	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	ND		1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Penicillium	+	+	-	-	25	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	+	+	-	ND		4	-	-	-	1	-	-	1	-	-	-	-	-	-	-	2	-	-	-
	-	+	-	+		3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
	-	+	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	-	+	-	ND		13	-	-	1	3	-	-	1	1	1	1	-	-	2	-	3	-	-	-
	-	-	-	+		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	-	-	-	ND		1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Rhizopus	-	+	-	+	6	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	-	+	-	ND		4	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	-	-	-	ND		1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scopulariopsis	+	+	-	+	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
	+	+	-	ND		2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	-	+	-	ND		1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	ND	ND	ND	ND		1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Sodaria	-	+	-	+	3	3	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-

Tilachlidium	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Torula	+	-	-	ND	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
Trichoderma	-	+	-	ND	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
	-	-	-	ND		2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
Filamentous yeast, unclassified	-	-	-	ND	3	3	[4]2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	
Filamentous fungi, unclassified	+	+	-	+	24	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
	+	+	-	-		2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	
	+	-	-	+		1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
	+	-	-	-		2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	
	-	+	-	+		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
	-	+	-	-		2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	
	-	+	-	ND		2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	
	-	-	-	+		6	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	2	-	-	
	-	-	-	-		5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	-	1	
	-	-	-	ND		2	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	
Total No. isolates					214	214	18	13	7	14	7	13	15	9	10	4	7	10	20	8	17	23	3	16	
Total No. positive	27	118	0	38																					
Total No. tested	198	198	198	64																					

[1]Biochemical capabilities: zein = zein hydrolysis, starch = starch hydrolysis, cellulose = cellulose degradation, lipid = lipid (corn oil) hydrolysis. In table, -, +, ND = test negative, positive, or not done, respectively. [2]FLW and runoff samples collected: 1, Sept 1970; 2, Nov 1970; 3, Jan 1971; 4, Mar 1971; 5, May 1971; 6, July 1971. In table, - = no isolates in sample. [3]FLW spread on field previous winter. [4]Each isolate represents 20 percent of total yeast plus fungus count in sample.

Organisms in runoff and associated sites

The dominant microorganism in runoff samples and the field ditch sample at Feedlot J was the diphtheroid, group 1-biochemical type 1, but its proportion of the total population was reduced by one-third when compared with FLW populations. The single, G^+ small rods of group 5 decreased as the proportion of the single, G^- small rods of group 7 increased. Cocci of groups 8, 10, 12, and 13 were present in significant numbers in individual samples.

The distribution of types of organisms in pen dirt was the same as that in FLW. The population profiles of the stockpile—composted FLW—and field samples were characterized by the single, G^- small rods of group 7. The diphtheroid, group 1-biochemical type 1, was found inconsequentially only in the March-field sample. Streptomycetes, group 15, were present in both field samples, in significant numbers in the September sample, but not in the stockpile sample.

Biochemical capabilities of the aerobes

Carbohydrate fermentations.—The aerobes from all sources were active in fermenting carbohydrates. Glucose, xylose, and lactose were attacked by 62, 38, and 28 percent of the 467 isolates. The 185 major isolates (those representing more than 10 percent of the total population of one sample) were similarly active: 70 percent fermented glucose, 42 percent xylose, and 29 percent lactose. Only 2 of the 176 xylose fermenting isolates did not ferment glucose. Of the lactose fermenting isolates, 92 percent also fermented glucose and xylose. The remainder were glucose positive only.

Because use of aureomycin on cattle feedlots affected the distribution of microscopic groups of isolates in the population, it also affected the fermentative capabilities of these populations. However, no apparent differences existed between the pristine (AP) and surface (A) samples from Feedlot A. Aureo-isolants (isolates from Feedlots A (both A and AP samples), D, and E that used aureomycin in the feed) were more reactive than abf-isolants (isolates from the antibiotic-free Feedlots B, C, G, and J, which used no antibiotic in the feed); reactivity of combio-isolants (isolates from Feedlot H, which incorporated combiotic in the feed) was in between. Glucose, xylose, and lactose were fermented by 81, 70, and 45 percent of both total and major aureo-isolants. The irregularly shaped G^v rods of group 2 and the small single G^- rods of group 7 accounted for 25 and 20 percent of the active aureo-isolants; the diphtheroids of group 1 and the small single G^+ rods of group 5 each accounted for 10 percent of the activity.

The abf-isolants were substantially less active, with 62, 27, and 24 percent of the total abf-isolants respectively fermenting the hexose, pentose, and disaccharide; 74, 23, and 19 percent of the major isolates reacted on the same substrates. The dominance of group 1-biotype 1 isolates in abf-isolants was the prime cause of the relatively high percent of glucose fermentation but low activity on xylose and lactose. Isolates from groups 2 and 5 each contributed about 25 percent of the total fermentative capabilities of the abf-isolants with isolates from groups 1 (except biotype 1) and 7 each accounting for about 15 percent of the total.

Glucose was fermented by 65 and 55 percent of the total and major combio-isolants, xylose by 48 and 45 percent, and lactose by 26 and 18 percent. Combio-isolants from groups 5 and 7 shared 70 percent of the total activity.

The fermentative capabilities of hog-isolates were comparable with FLW-isolates; 78, 47, and 44 percent of all hog isolates attacked glucose, xylose, and lactose. Correspondingly, 71, 50, and 42 percent of the 24 major hog-isolates were active. Two-thirds of the fermentatively active major hog-isolates were from groups 3 (large G^- rods in palisades), 4 (large G^+ rods), and 14 (yeasts). Of all active hog-isolates, 11 percent were from group 7 (small G^- rods) and the remainder were scattered through six additional groups.

The fermentative capabilities of the run-off isolates and pen dirt isolates, both from Feedlot J, were about one-half those of abf-isolants. Similarly, distributions of these active isolates were largely in groups 1, 2, 5, and 7.

The percent of isolates capable of fermenting carbohydrates diminished over time in soil containing FLW. Fifty percent of the isolates from the March-field sample (FLW applied 1 to 3 months previously) were able to attack glucose with fermentative isolates distributed among groups 1, 2, and 7—three of the four dominant groups in abf-FLW. When the same field was sampled 6 months later, only one-third of the isolates fermented glucose and only the small G^- rods of group 7 remained of the four groups which characterized abf-FLW. Only 1 isolate (group 7) of 13 recovered from the stockpile, composted FLW, was able to ferment glucose.

Nitrate, indol, and H_2S.—Nitrates were reduced

by a moderate number of all isolates while indol and H_2S were produced by a few isolates, primarily hog-isolates and aureo-isolants. Nitrite, indol, and H_2S were produced by 42, 6, and 2 percent of all isolates. The major isolates were slightly more active in producing these compounds (44, 9, and 3 percent).

Again abf-isolants differed from aureo- and combio-isolants in FLW samples; commonly, two-thirds of the nitrate reducers in all FLW samples fermented glucose. Nitrite and indol were produced by 43 and 2 percent of all abf-isolants and by 68 and 4 percent of the major abf-isolants; no H_2S production was detected. Group 1—essentially all biotype 1—and group 5 isolates each represented 30 percent of all nitrate-reducing abf-isolants; and, isolates from groups 2 and 7 represented an additional 15 and 12 percent of the total. Essentially all group 1 and one-half of the group 5 isolates that reduced nitrate were glucose positive as were two-thirds of the isolates from groups 2 and 7. Almost all of these isolates fermented glucose only. An exception was two indol positive abf-isolants from group 7 that reduced nitrate, fermented lactose, and produced acid and gas from glucose. The other indol-forming abf-isolant was a nonfermenting diphtheroid of group 1.

Nitrate was reduced by 39 percent of all combio-isolants and 45 percent of the major isolates. Isolates were scattered among the microscopic groups. Only one combio-isolant produced indol; the group 7 organism was nitrate negative.

Nitrite and indol were produced by 38 and 12 percent of the aureo-isolants and by 33 and 16 percent of the major isolates. H_2S was produced by one group 4 isolate (large G^+ rod, chains). About 30 percent of the nitrate-reducing aureo-isolants were group 7 cultures and groups 1, 2, and 5 each added another 15 percent. More than half of the nitrate-reducing aureo-isolants that fermented glucose also fermented xylose or lactose, or both. All 14 indol-forming aureo-isolants also reduced nitrate, fermented lactose, and produced acid and gas from glucose. There were two isolates each in group 3—(large G^- rods in palisades) and group 5—(small, single G^+ rods); the remainder were the small, single G^- rods of group 7.

Organisms from hog waste were less active than were FLW isolates in reducing nitrates but were substantially more active as indol and H_2S producers. Nitrite, indol, and H_2S were produced by 24, 16, and 16 percent of all hog-isolates and by 17, 17, and 21 percent of the major isolates. Two-thirds of the nitrate-reducing isolates, including all the indol-formers, fermented lactose and glucose—usually with gas produced. These were the large and small G^- rods of groups 3 and 7. The seven H_2S-producing isolates were distributed among groups 3, 4 (large G^+ rods), 7, and 8 (G^+ cocci in chains). All fermented the three carbohydrates and most were nitrate negative.

Runoff isolates were comparable to abf-isolants in both capabilities and distribution of active cultures among the microscopic groups.

Forty-five percent of all 64 isolates from the associated sites of Feedlot J reduced nitrate. None were capable of producing indol or H_2S. One-half of the nitrate-reducing isolates attacked glucose only; one-third fermented no carbohydrate. Nitrate was reduced by more than 60 percent of the cultures from pen dirt, the March-field, and the field ditch; less than 30 percent of the isolates from the September-field and the stockpile were active. Distribution by microscopic groups within and among samples was dispersed.

Degradative capabilities of the aerobes

Breakdown of zein, starch, cellulose, lipid (corn oil), and urea was considered an indication of the ability of constituent organisms to decompose waste. The aerobic isolates were mildly effective in this regard. Zein, starch, lipid, and urea were degraded by 14, 18, 8, and 11 percent of all isolates; major isolates were slightly less active. Cellulose was not attacked by any isolate. The results are summarized by source and by microscopic group in table 27.

As a measure of proteolysis, zein hydrolysis was a more sensitive indicator than was peptonization of litmus milk. Two-thirds of the zein-positive isolates did not peptonize milk. But seven zein-negative isolates peptonized milk, increasing the total proteolytic capabilities to 16 percent of all isolates. The seven isolates were from hog waste or from associated sites at Feedlot J.

Lipase activity with corn oil as substrate was not run on all samples from Feedlot J. Isolates from these samples are recorded as lipase negative. Thus lipase activity for abf-isolants and run-off isolates may be low by 10 and 57 percent.

FLW isolates.—Distribution of degradative capabilities among FLW isolates was affected by incorporation of antibiotics in feed. The percentage of abf-isolants able to degrade zein or milk, starch, lipid, and urea was 17, 17, 9, and 8. In percentage of cultures having degradative capabilities, combio-isolants were twice as effective as abf-isolants in de-

grading zein, starch, and urea but were only half as effective in degrading lipid. Aureo-isolants on the same basis were only 60 percent as effective as abf-isolants in degrading zein and starch but had twice the capability of degrading lipid; and, they were one-third more effective than abf-isolants in using urea.

One-third of all degradative isolates were the small G^+ rods of group 5 and one-fourth were the small G^- rods of group 7; the irregularly shaped rods of groups 1 and 2 constituted an additional fourth. Zein hydrolyzers, one-half from group 5, were characteristically nitrate negative and ambivalent in fermentation of glucose. Starch hydrolyzers, half from groups 5 and 7, were usually nitrate positive (group 7 isolates were largely nitrate negative) and characteristically glucose positive.

Significant numbers of abf-isolants from groups 1 and 2 provided the higher starch-hydrolyzing capacity of these isolants than that exhibited by aureo-isolants. Two-thirds of the lipase positive FLW isolates were from groups 2, 5, and 7 and one-half of the urease producers were in groups 2 and 5. FLW isolates that produced lipase typically fermented glucose and were mixed in their ability to reduce nitrate; urease-producing isolates usually reduced nitrate but were variable in their ability to attack glucose. Of the lipase- and urease-producing isolates, the group 7 isolates were characteristically nitrate negative, group 5 isolates typically fermented glucose, and group 2 isolates typically attacked either nitrate or glucose.

Hog waste isolates.—Of the hog isolates, 10, 20, 2, and 4 percent were capable of degrading zein or milk, starch, lipid, and urea. The single lipolytic isolate was a yeast. The large G^- rods in palisades (group 3) were the only major isolates possessing degradative capabilities, accounting for more than one-third of the activity on zein or milk, starch, and urea. Diphtheroids (group 1) and small G^+ rods in chains (group 6) hydrolyzed starch and small G^+ or G^- rods (groups 5 and 7) attacked zein, starch, or urea. Essentially all degradative isolates fermented glucose and all except the yeast and streptobacilli reduced nitrate.

Runoff isolates.—Zein, starch, lipid, and urea were degraded by 10, 24, 3, and 14 percent of the runoff isolates. Diphtheroids (group 1) and cocci (groups 8, 10, 11, and 13) represented one-half of the active isolates and almost all of the major isolates. Of those organisms degradatively most active among FLW isolates (groups 2, 5, and 7), only members of group 7 were present in runoff in significant numbers, representing one-third of the isolates. The degradative cultures were typically nitrate negative and usually did not ferment glucose.

Isolates from associated sites.—The percent of degradative isolates from these samples, taken collectively, was slightly larger than that for abf-isolants. However, over half of these major isolates had degradative capabilities. Zein was degraded by major isolates in samples from the September-field (a streptomycete), stockpiled FLW (a small G^- rod), and the field ditch (a yeast). Group 7 major isolates from core samples of the March-field, September-field, and stockpile hydrolyzed starch. A streptomycete from the September-field sample and a small single G^- rod from the feed degraded lipid and urea, respectively.

Microscopically, half of all degradative isolates from associated sites were small single G^- rods. They typically attacked neither nitrate nor glucose, and were common in feed but not recovered from the field ditch. In core samples the group 7 isolates increased in frequency with aging of the FLW application, being absent in pen dirt, common in the field samples, and constituting all of the degradative stockpile isolates.

Yeasts, fungi, and streptomycetes from Feedlot J

Populations of the more complex microbes from Feedlot J were also enumerated and examined for degradative capabilities. Total counts of yeasts, fungi (molds and macroscopically filamentous yeasts), and streptomycetes are in table 16.

Yeasts.—Although most prevalent of the three classes, yeasts were the least active degradatively (table 29) and were inferior to the bacteria in this respect. Eight percent of the 63 isolates hydrolyzed starch and 5 percent (15 percent of those tested) produced lipase. Cellulose and zein were not degraded, but two isolates peptonized milk. Almost all isolates fermented glucose whereas urea and nitrate were each attacked by one-sixth of the yeasts.

Fungi.—Fungal isolates (table 30) were good starch and lipid degraders, hydrolyzed zein on par with the total aerobes, and were inactive on cellulose. Three-fifths of the isolates tested degraded starch or lipid, and 14 percent hydrolyzed zein. Forty-four percent of all isolates capable of degrading zein or starch were either *Aspergillus* or *Penicillium* spp. although these genera represented only 31 percent of all fungal isolates. All *Absidia* and *Scopulariopsis* spp. tested attacked both starch and lipid and most of the latter also degraded zein. Two-thirds of the proteolytic and lipolytic activity

was derived from one-third of the isolates—the soil isolates from pen dirt, field samples, and stockpile. Only one-third of all fungal isolates did not attack one of the four substrates; in comparison, two-thirds of the total aerobes were nonfunctional.

Streptomycetes.—The most active group studied was the streptomycetes (table 28). Zein, starch, and lipid were degraded by 45, 77, and 52 percent of isolates tested. As with all other isolates tested, no streptomycete attacked cellulose. FLW isolates were about 10 percent more active on all three substrates than were the total array of streptomycetes. Isolates from the stockpile were unusually active on both zein (80 percent) and starch (92 percent). Only 16 percent of the streptomycetes did not attack one of the four substrates and half of these were from the March-field sample.

Salmonella detection

Salmonella was detected in samples collected from Feedlot B and the AP sample (pristine) from Feedlot A in summer 1972, although the A (manure pack) sample collected at the same time was negative. Both the serologic and biochemical tests used were positive for *Salmonella*. Either *Salmonella* or *Arizona* was isolated from samples collected from Feedlot B in summer 1971 and in spring 1972. These isolates gave positive serologic tests for *Salmonella,* but biochemical tests included positive malonate and negative beta-galactosidase reactions. *Salmonella* were not detected in the 36 other samples from Feedlot A to I including all samples collected in winter 1972. *Salmonella* and *Arizona* were detected in FLW but not in runoff from Feedlot J.

Antibiotic detection

Furazolidone was not detected (<0.002 μg/g dry wt) in the hog waste sample from Feedlot I.

Chlortetracycline was not detected in the six FLW samples from Feedlots A and E. Aureomycin was used on Feedlot A only during the first 30 days of the animals' stay on the feedlot. Since arrival time of the animals was not ascertained, these samples probably were obtained from animals on feed without aureomycin. Similar circumstances may apply for samples tested from Feedlot E. Also, although the time required for its reappearance in FLW following antibiotic usage was not determined, the diphtheroid characteristic for abf-FLW samples (group 1- biochemical type 1) was isolated from one of the samples taken at this time.

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